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Technological capability development from an information perspective: a case study of the social and technical dimensions of engineering in the Pacific Islands

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Technological Capability Development from an Information Perspective

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In memory of my late father,

GERARD HENDRIKUS TIBBEN

1919 - 1998

ABSTRACT

This thesis investigates the social and technical aspects of engineering in a Pacific Island broadcasting organisation. The analysis focuses on problem solving and the ways in which the organisation is seen to facilitate and constrain the problem-solving endeavours of its engineers. The concept of technological capability provides the theoretical framework for the investigation. Two significant studies on technological capability are referenced to both studies of engineers and the literature on Pacific Island development. The three dominant Pacific themes of "smallness", "isolation" and "resistance to change" are used to reveal impediments to the development of technological knowledge in Pacific Island engineers. The thesis responds to these findings by outlining an information-based conceptual framework which focuses on the transfer and acquisition of problem solving information. The study leads to the conclusion that the difficulties experienced by the engineers in procuring tangible goods is symptomatic of a deeper problem in procuring "intangible" problem solving information. The thesis delves into the social dynamics which accompanies the technical complexities of equipment faults and argues that the organisation is influential in mediating the acquisition of problem solving information. The organisation emerges as critical in the resolution of problems and hence, capability development. The case study shows that the broadcasting organisation is largely a creation of local circumstances (historical, political and cultural). This has important implications for explanations of technology development and diffusion in developing countries generally. An information perspective of technological capability development enables "the organisation" to be incorporated into theoretical models of technological capability development. The research design is orientated to theory building through case study analysis. The units of study are engineering personnel, the organisation in which they work and the technological artefacts they manage. Data-gathering in the field comprised of participant observation, interviews and content analysis of documentary sources.

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Preface and Acknowledgments

The impetus for this thesis comes from my four year association with a radio station in Samoa as a technical adviser. The experience left me with many questions about the problems associated with making technologies work in environments which are quite different from those for which they were nominally designed - that is, countries in the more temperate regions of the world which are of sufficient size to support manufacturers, distributors and the like. As technical adviser, my role as "expert" often seemed at odds with my experience in that I often felt that there was much I didn't know about the particular challenges of working with limited resources in a relatively isolated part of the world. Forming friendships with people whose cultural heritage differed from mine, among other things, raised questions about the relevance of the radio station to this community, particularly my role as a broadcast engineer. Living in surroundings which are best described as rural was also a different experience for me as I had only worked in broadcasting organisations in city centres of Australia. I still carry a vivid image of the chickens and pigs which were obliged to move out of my path as I was taken for the first time across the road to view the radio station's new transmitter facility. I realised just how different this was from the surroundings of broadcasting organisations I had become accustomed to.

The radio station at the time of my arrival was recovering from a cyclone which had caused considerable damage seven months previously. Tragically, a member of the technical section was permanently incapacitated as a result of an accident which occurred while he was attending to the repair of transmitters on the island of Savai'i just after the cyclone. While the radio station was using its newly installed transmitter facility, the quality of signal being fed to these transmitters for broadcast by the studio equipment was poor. I was informed that most of the items of studio equipment were no longer

supported by their manufacturers. This immediately put a different slant on my expectations as I was endeavouring to introduce some "science" into the technical section by demonstrating how effective periodic testing and alignment was in maintaining signal quality. I quickly became aware that much of the equipment was so badly worn that the equipment manual was only marginally instructive about the behaviour of these machines and that local methods had been devised by my counterpart to keep the equipment running.

Another important influence on my experience as a technical adviser to the radio station was that my arrival came after a period of down sizing. Predating similar initiatives in other local organisations by about 10 years, the consequence was that much of the accumulated knowledge in the technical section had exited the radio station with the departure of a number of key individuals. This provided the explanation for my presence as the technical section was solely dependent on my counterpart.

A second devastating cyclone just 14 months after my arrival marked a significant turning point on two counts. As most of the studio equipment was destroyed, equipment destined for a rural radio project was pressed into service in the main studio. This meant that much of the troublesome equipment was disposed of and the radio station could concentrate on improving its on-air sound quality. Another major event was the return of a newly qualified trainee from studies in Australia and the simultaneous departure of my counterpart to take up work in New Zealand. This trainee was quickly promoted to the chief engineer's position and became my counterpart. I worked with the chief engineer for a further two years before I returned to Australia.

University studies opened up my mind to possible avenues by which to explore questions I had developed while working in Samoa and later, other Pacific locations. To the extent that I had played a small part in a process which I came to know as technology transfer or technology diffusion sparked within me a desire to become better acquainted with the

theory of the social aspects of technological change. The research began as an investigation into the possible roles the Internet might provide for Pacific Island engineers but gravitated to one of looking more specifically at the information needs of Pacific Island engineers and the factors governing the transfer of information. The thesis suggests a number of implications for Internet-related research.

I owe much to the people whom this study describes. It is difficult to describe in words the richness of my experiences which I attribute largely to the warmth of relationships I developed with many people. Without their early encouragement and support, this project would not have even begun.

Present throughout my earlier experiences in Samoa as well as the writing of this thesis has been my wife Jennifer. Without her cooperation, encouragement and patience, it is doubtful whether this project would have ever been completed. Thank you. Thank you to my children for their understanding, particularly when I wasn't around. Special thanks are also extended to my father-in-law, John Robbins, for his contribution of proof reading final drafts.

The completion of this thesis depended vitally on the support of my supervisors, Joan Cooper and Tim Turpin. Their comments and criticism have been a constant source for reflection and learning.

I am especially grateful for the encouragement provided by Richard Joseph for initially opening my mind to the possibilities of an information-based approach. Since then, his perceptive intellect has invariably been a source for new and interesting ideas which often rejuvenated my flagging interest.

The support of the Pacific Island Broadcasting Association (PIBA) in this research, especially Hendrik Kettner, was instrumental in making contact with Pacific Island broadcast engineers from a number of countries. Finally, I am grateful to Fujitsu Australia for providing me with a scholarship which was used for air travel to Samoa to conduct interviews.

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Chapter 1

Introduction

1.1. INTRODUCTION

This thesis is about a group of Pacific Island engineers[1] and the challenges they face in keeping the machines and equipment of their organisation operating. It examines the organisation in which they work and the purposes that the organisation endeavours to fulfil in local society. The thesis seeks to understand how the engineers' interactions with the organisation and the technological artefacts influence the development of technological knowledge in these practitioners.

The significance of research into this topic is reflected in the increasing use of western technologies by Pacific Island communities (Marjoram, 1994a). For good or bad, the adoption of these technologies suggests that individuals, families and communities rely on the operation of technological artefacts, delineating an important role for the engineer.

[1]In this thesis, the use of the terms engineer and technician refer to relative positions of authority and do not necessarily reflect the qualifications of the individuals referred to. This stands in contrast to the distinctions drawn by bodies such as the Institute of Engineers (IE) and the Institute of Electrical and Electronic Engineers (IEEE) between professional, technologist and associate status on the basis of qualifications (i.e engineering degree, diploma, associate diploma etc). The approach adopted in this thesis draws support from Whalley's (1986, pp. 20 & 53) study which argues that the organisation is influential in determining relative levels of authority. The distinctions employed in this thesis are similarly argued to be more appropriate for the situation in the Pacific. As there is a scarcity of qualified individuals, practitioners are often required to fulfil a wide range of responsibilities, as the need arises. This is clearly reflected in membership of the Pacific Island Broadcasting Association (PIBA) Engineering Committee which is conditional on organisational status rather than qualifications. In addition to this, the use of generic terms rather than actual designations goes some way to maintaining the anonymity of the individuals concerned.

In rural areas, increasing reliance on pumps and motors determines a need for what Marjoram (1994b, p. 146) describes as the '...barefoot engineer...'. In urban areas, technologies such as communication systems have required the services of engineers who are able to understand the workings of more complex electronic systems. Strangely, only vague renditions of the role and purpose of the Pacific Island engineer is found in the literature. In terms of giving these practitioners a voice, there is still much to be done in recording and understanding their stories.

The latter of the two groups of engineers just described is the focus of this investigation. The engineers under study work for a broadcasting organisation in the Pacific country of Samoa. Broadcasting is one example of a global technology which is used extensively around the world to promote communication within and between countries (Pavitt, 1995, p. 1). The literature is divided in its assessment of initiatives which rely on global technologies to bring about beneficial change. Writers who are supportive of such measures celebrate the process of "modernisation" as one in which Pacific Island communities are forced to conform to western models of social organisation through their use of western technologies. On the other hand, opponents of such strategies view foreign technologies as divisive and destructive of local cultural norms. Each scenario implies a different social role for the engineer and the organisation to which he or she belongs - in the former, the engineer is distinguished by the "constructive" role he or she plays while the latter views him or her as unwittingly undermining local culture. The thesis argues that coming to an understanding of these local processes concerning the adaptation of western technology is important. These processes have implications for the ways in which engineers respond to equipment problems and the manner in which their organisation is able to support them in this task.

The thesis focuses on technological capability development as an avenue to explore the training and development of engineers. Problem solving is identified as an important contributor to the knowledge of engineers. Complementing experiential learning is

communication with other knowledgable practitioners, which is important in transferring experientially-derived knowledge between engineers. Recognition of two important attributes of technological knowledge, codified and tacit knowledge, is necessary for an understanding of one of the major issues which drives this investigation. As the literature maintains that the tacit components of technological knowledge are most difficult to transfer, the thesis focuses on the development of this aspect of technological knowledge.

The second major issue driving this research is concern over the dominant characteristics of the Pacific region and the influence these factors have on the transfer, application and development of technological knowledge. The themes of "smallness", "isolation" and "resistance to change" (Higgins, 1994) serve the purpose of providing the analysis with "touchstones" with which the theory of capability development must engage if it is to have meaningful connotations for Pacific Island engineers. "Smallness" reflects the limitations imposed on opportunities for knowledge sharing among Pacific Island engineers. "Isolation" speaks most directly to the problem of enabling the transfer of technological knowledge over large expanses of ocean. The theme of "resistance to change" signals a more complex research problem of how the social dynamics of technology diffusion influence the development and application of this knowledge within the specific contexts of the engineers' organisation and community.

In summary, the research problem that this thesis explores is how Pacific Island engineers solve problems within the context "smallness", "isolation" and "resistance to change". In doing so, the study seeks to promote an understanding of the broader social process of technology diffusion from an organisational perspective and to reveal the relationship these processes have with the development of technological knowledge in its engineers. By addressing this question, the thesis hopes to contribute to initiatives which aim to develop technical expertise in the Pacific region, broadcasting being one such area of need (Lie et. al., 1996, p. 20; Molnar, 1994, pp. 106-107; See also Preface).

The units of study are the engineering personnel, the technologies they use and the broadcasting organisation within which they "work". A case study methodology is adopted which is oriented towards theory building. Data gathering in the field consisted of participant observation, interviews and content analysis of documentary sources. The work of Macdonald (1992; 1995; 1998a; 1988b) is used as an analytical tool by which to interpret the case study data. Macdonald focuses on the specific roles of information during problem solving which he describes by the term, "information perspective". Implicit to Macdonald's understanding of problem solving is the idea of information possessing characteristics quite unlike those of a conventional economic goods. How individuals and organisations respond to these characteristics is viewed as having important implications for the ways in which individuals solve problems and learn.

1.2. DEFINITIONS AND ASSUMPTIONS

The need to specify definitions and assumptions is largely derived from imprecise meanings attributed to the term "technology". As Murphy (1967, p. 6 cited in Al-Ali, 1995, p. 707) explains, definitions of technology fall into three main areas.

> [T]he simplest version views technology as involving only changes in artifacts. A more sophisticated approach adds to the physical objects, labor and managerial skills...A third approach views technology as a "socio-technological" phenomenon; that is besides involving material and artifact improvements, technology is considered to incorporate a cultural, social and psychological process as well.

Despite the prominence of engineers in this study, the thesis adopts a definition of technology which is broader than one might ascribe to engineers. Even though the engineer's concern is naturally on the physical objects of technology, the scope of the study includes the interactions that occur between people and these objects within specific contexts, such as the organisation. While the need to consider labour and managerial skills falls within this ambit, attention to the broader societal implications of technology diffusion also alludes to the socio-cultural aspects of Murphy's definition (although the thesis does not delve into the area of psychology). In making reference to the physical objects of technology the terms "technological artefact", "artefacts of technology", "machine" and "equipment" will be used interchangeably to refer to what Macdonald (1983, p. 26) describes as the '...inanimate shaped to perform useful tasks...'.

Attempting to better define the nature of broadcasting technology, the terms "modern" and "western" are used to delineate such technologies from local and traditional technologies. Both adjectives are insufficient: modern is unsatisfactory because broadcasting technology dates back many decades; western is unsatisfactory in that much broadcasting equipment emanates from "eastern" countries such as Japan. While the description of "industrial" technologies may be more accurate in that broadcasting technologies are produced in industrialised countries[2], the adjective of industrial sits oddly with the idea of broadcasting because of its association with smoke stacks and heavy industrial machinery. Hence, the terms "modern" and "western" will be used, partly because they are used in a number of texts and also because they clearly indicate imported technologies from developed countries.

[2] Badham (1984, p. 88) argues that the description of industrialised is similarly difficult to define.

1.3. THE STUDY

The study is best situated under a research agenda outlined by the development economist Cooper (1994), who proposes that studies of innovation within organisations in developed countries can be used for guidance in understanding barriers to learning within organisations in developing countries. Cooper's research agenda is reflected in this thesis in two ways. Firstly, and of primary significance, is the focus on the organisation and its central role in promoting the learning of technological capabilities. Cooper (1994, pp. 6-7) states that the organisation is an appropriate analytical unit because it provides a formal context which accounts for the localised and cumulative nature of technological learning. In short, organisations have different and unique attributes which influence the nature and direction of current and future knowledge development. Secondly, Macdonald's (1992; 1995; 1998a; 1988b) information perspective is used as an analytical tool to interpret the case study accounts. Macdonald has developed his perspectives on information from his study of innovation in a wide range of geographic and historical contexts, ranging from seventeenth century agriculture in Britain to the dynamic firms of Silicon Valley in the United States.

While affirming the need for formalised education and training strategies, the thesis argues that the ultimate test of technological capability is its manifestation in the organisation through problem solving. Problem solving emerges from this thesis as an important knowledge development process. The centrality of problem solving reflects the uncertainties which arise when dealing with machines and equipment. As this learning occurs within the organisation, closer attention to the processes which contribute and detract from problem solving are important in understanding the development of technological capability in engineers.

Support for these contentions is drawn from the investigation of two major studies on technological capability (Enos, 1991; Bell and Pavitt, 1993). The thesis initially

compares these two studies with empirical studies of engineers to determine their adequacy in relation to the experience of engineers. The organisation emerges from this analysis as an important place in which technological capability is created because of the goals it establishes for the engineers to follow and the influence it has over their work.

The thesis then seeks to determine the extent to which the two studies of technological capability by Enos (1991) and Bell and Pavitt (1993) are amenable for application in the specific contexts of the Pacific region. The three themes of "smallness", "isolation" and "resistance to change" are used to reveal difficulties associated with tacit knowledge development in the Pacific region which are not addressed in the two studies of technological capability. The existence of "smallness" raises questions about organisational size and whether sufficient resources in the form of spare parts, funds and most importantly, other experienced personnel, are present to enable engineers to carry out their work. "Isolation" is argued to be detrimental to the development of tacit knowledge because of the constraints that distance places on communication with experienced practitioners overseas. "Resistance to change" refers to the uncertainty surrounding the nature and goals of the Pacific Island organisation. As the literature is divided over the processes that constitute the community-wide process of technological adaptation, the thesis responds by developing three alternative portrayals of the "quintessential" engineer as a means of clarifying the different social roles implied for the engineers and the organisation. This is used in the later analysis of research data to determine which scenario best explains the situation of the case study organisation and its engineers. These alternative portrayals have been titled "Cadres of Modernisation", "Pawns of a Global Hegemony" and "Part of the Pacific Way".

On this basis the analysis seeks to better understand what constitutes the experience of problem solving by the case study engineers within the constraints imposed by "smallness", "isolation" and "resistance to change". Macdonald's information perspective is used as an analytical tool to interpret the case study accounts because it

responds to three major issues identified from the literature: the importance of problem solving in technological knowledge development; the need for communication with experienced "others" outside the organisation; and the uncertainty surrounding the goals to which Pacific Island organisations and their employees are directed.

The analysis of case study accounts argues that there is a social and technical dimension to the engineers' experience of problem solving. Looking at the technical dimension of problem solving first, the analysis of a case study problem solving example reveals a deficiency of information in the organisation and identifies the need for problem solving information which is external to the organisation. The thesis argues that the difficulties the engineers experience in acquiring tangible goods is symptomatic of a deeper problem in procuring intangible problem solving information. The thesis finds that there are a number of material and non-material costs to acquiring and using information which are related to the dynamics of the organisation and the equipment suppliers it must deal with.

In view of the organisation's effect on problem solving, the analysis proceeds to examine factors which shape the organisation. The discussion argues that while the organisation ostensibly reflects broadcasting organisations in western countries, closer scrutiny of issues internal to the organisation, and in the broader community, suggests that it is more a creation of local political, historical and cultural circumstances. The process of technology diffusion is argued to be a locally-centred problem solving process which has unique attributes. The engineers of this study represent a group who are important to this learning process suggesting that they are subject to local authority ("Part of the Pacific Way"). In that the organisation is argued to make demands for the machine to work in a manner which is reflective of local values, the machine also demands a set of relationships which extend to equipment manufacturers and distributors overseas. The thesis ultimately portrays the engineers as standing at the cusp of two cultures, their own and that of the culture from which the technological artefacts were obtained. Accordingly, a proficiency in both cultures is a necessary quality for these engineers.

The contribution that this thesis makes to the literature is twofold. Within the context of Cooper's original proposal for a development research agenda informed by the studies of innovation, it is evident that the application of Macdonald's information-based rationale to this case study material yields insights into the effect of the organisation on problem solving. The thesis provides an avenue by which to integrate the Pacific Island organisation, shaped by its particular historical and circumstantial contingencies, into theoretical models of technological capability development. Macdonald's information perspective is argued to be effective in doing this as it is able to simultaneously respond to the locally determined nature of problem solving in the organisation and recognise the necessity for external problem solving information in the resolution of such problems.

Moreover, the thesis moves beyond Cooper's research agenda and addresses current concern over development discourse and its preoccupation with western culture. Scholars, such as Castles (1999), wish to see an analytical framework that is better able to account for the role of local societies in circumstances which are increasingly dominated by events and technologies of a global nature. The thesis proposes Macdonald's information perspective as an appropriate analytical tool because of its attention to the factors which govern information transfer from the external into the local.

The purpose of this thesis, therefore, is to develop a deeper awareness of the challenges to Pacific Island engineers in solving problems in their organisation. This task is broken down in a number of steps which are reflected in the topics considered by each of the following chapters. The thesis sets about developing this awareness by initially assessing established theory for its response to the circumstances of Pacific Island engineers. Chapter 2 begins with a description of two studies of technological capability development by Enos (1991) and Bell and Pavitt (1993) which encapsulate the major issues under contention. With reference to empirical studies of engineers, the analysis proceeds to assess the extent to which the two studies account for the experience of

engineers as an occupational group. Chapter 2 concludes that tacit knowledge development through experience and communication between engineers is an important component of technological capability development. There is sufficient reason to distinguish this form of learning in the organisation from the learning which occurs in more formal settings, such as educational institutions and training courses.

In Chapter 3, the two studies of technological capability are assessed for their response to the specific conditions pertaining to the Pacific. The themes of "smallness", "isolation" and "resistance to change" are introduced and used to raise questions about the fundamental assumptions on which the two studies are based. The reality of small organisational size and isolation from more experienced practitioners is viewed as being detrimental to the development of technological capability in engineers. Chapter 3 goes on to explore the deeper social implications of technology-based change, represented by the term "resistance to change". To better clarify the issues involved, the chapter develops three alternative portrayals of the quintessential engineer, drawn from the competing areas of Pacific Island development discourse: "Cadres of Modernisation", "Pawns of a Global Hegemony" and "Part of the Pacific Way". These alternative portrayals are subsequently used to determine which best reflects the situation of the case study engineers.

The dominant issues to emerge from these two chapters are summarised in Chapter 4 in the principal research question, "how do engineers solve problems within the Pacific contexts of smallness, isolation and resistance to change?". Four further research questions are developed to illuminate different aspects of this question suggested by the literature review: the social and technical dimension of the engineers' work; the organisation's influence over their problem solving endeavours; and the influence the broader community has over the organisation and the engineers. An interpretive research methodology is explained, as then is Macdonald's information perspective, which is used as an analytical tool to interpret the case study research data.

The next three chapters contain the case study accounts and analysis. After familiarising the reader with the research design and context of the case study organisation, Chapter 5 proceeds to explain the significance of the social and technical dimensions of problem solving to the case study engineers.

Chapter 6 examines a problem solving example and uses Macdonald's information perspective to argue that the experience of complexity is associated with deficiencies in problem solving information. The chapter then proceeds to argue that the case study engineers are constrained by factors which relate to the organisation and its relationship with overseas suppliers. Chapter 6 concludes by stating that the development of technological capability in the case study engineers is more than just a question of individual ability but also relates to the capabilities of the organisation to acquire problem solving information.

Chapter 7 looks to the broader context in which the organisation resides to gain some understanding of the processes that accompany the use of broadcasting technology in this local community. The chapter determines that out of the three portrayals of the "quintessential engineer" in Chapter 3, that which best reflects the experience of the case study participants is one where they are subject to the authority of local interests ("Part of the Pacific Way"). Accordingly, the organisation is argued to be a product of local historical and cultural circumstances. The implications this finding has for the engineers is that they are required to be adept in two cultures, the one in which they live and the one from which the technological artefacts they manage were derived.

Chapter 8 concludes the analysis. The two studies of technological capability are revisited in order to specify the areas in which further theoretical development is required. The most significant issue arising from this examination is the need to include in theoretical frameworks organisations like this case study organisation, which use western

technology but primarily serve local interests. The chapter goes on to argue that Macdonald's information perspective with its emphasis on problem solving and external information is an appropriate model by which to account for such an organisation. Additionally, the discussion proposes that Macdonald's information perspective has broader application in recent initiatives to develop an alternative analytical framework to development discourse. This issue is discussed in relation to Castles' (1999) work on social transformation. The thesis concludes with a discussion outlining areas for future research indicated by this study.

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Chapter 2

Technological Knowledge Development: A Critique of Two Studies of Technological Capability

2.1. INTRODUCTION

The processes which contribute to the learning of technological knowledge are central to the development of technological capability (Bell, 1984, p. 187; Boulding, 1966, p. 5; Fransman, 1986, pp. 7-10). This chapter summarises two important theoretical perspectives on technological capability development (Enos, 1991; Bell and Pavitt, 1993) and seeks to test these studies in the light of empirical studies of engineers, the occupational group at the centre of this study. The chapter argues that the knowledge developed from experience and communication represents an under-recognised but nonetheless fundamental element of technological capability. Its fundamentality springs from the uncertain characteristics of machines and equipment. The nature of the organisation emerges as being influential in determining the course of knowledge development for engineers.

The chapter begins by describing the two major studies (Enos, 1991; Bell and Pavitt, 1993) on technological capability development. From the extensive writing on the subject (Reddy et. al., 1990, pp. 291-292) the literature chosen for analysis is growth economics based. This focus is considered most germane in the light of Veramu's (1998b, p. 48) comments citing growth economics as being most dominant in the determination of development strategies for the Pacific region. The two studies chosen for analysis are

broadly analogous to what will be described as the change in the theory of technological capability development where increasing significance is devoted to the tacit components of technological knowledge and the environment in which this development takes place. The chapter then grounds these two studies within the research detailing the practices and experience of engineers. The analysis argues that experiential knowledge represents an important and distinct element of technological capability. Communication is important in transferring this knowledge between engineers. The chapter asserts that the organisation, by virtue of its influence over the engineers, represents an important actor in the development of technological capability.

2.2. THE STUDY OF TECHNOLOGICAL CAPABILITY

2.2.1 Overview

The period since World War II is notable for the application of technology-driven solutions to the problems of poverty and underdevelopment (Rosenberg, 1970, p. 550). As Fransman (1984, pp. 5-6) explains, the term "technological capability" has undergone significant revision during this time as new insights into the process of technology transfer have emerged. Early approaches tacitly assumed non-industrialised countries to have weak technological capabilities, the remedy of which was to import foreign technology. Technology was viewed in terms of a "black box" where the most important capabilities were considered those embodied within the artefact itself. The role of indigenous organisations and individuals in this process was to quickly fall in line by applying these externally developed technologies. The realisation that the effective operation of these technologies was reliant on networks of complementarities which penetrated many areas of social and economic life served to focus greater attention on the affects these technologies were having on local society (Streeten, 1982; 1993; for the

Pacific, see Hill, 1988; Marjoram, 1994a). Rather than establishing certainty in economic and social affairs, the transfer of technology was found to be responsible for introducing new areas of uncertainties (Fransman, 1984, p. 11).

These problems gave impetus to the idea of technological capability becoming an issue worthy of specific attention. The difficulties of developing technological capability were encapsulated within Nelson's (1978, cited in Fransman, 1984, p. 5) portrayal in which the seller always possessed more knowledge of the technology's operation than could ever be contained in the blue prints, operating instructions and training provided to the buyer. It was clear from Nelson's assessment that the partial success of the knowledge transfer process was attributable to the nature of this missing component of knowledge. In contrast to that which was codified in books, drawings and instructions, the missing knowledge component was less amenable to such codification as it was embedded in people's skills and organisational routines. Referred to by Lamberton (1998, p. 188) as a dichotomy, definitions of technological knowledge have accordingly endeavoured to account for its two part nature by distinguishing between its codified and tacit attributes, as seen in the definition Turpin et. al. (1995, p. 64) employ.

> Codified knowledge is characterised by its embodiment in technological artefacts, literature, technological processes and the like. Tacit knowledge on the other hand, is embodied in people and their skills, technical know-how and experience in solving complex problems.

Reasons why the tacit component remains unarticulated range from the difficulty in articulating all that there is to know, the limitations of language in describing relationships and things, or even perhaps, lack of time. Lamberton (1998, p. 189) observes that when moving beyond this basic reasoning, '...explanations shade into communicative failure, which in turn shades into understanding and the information-handling capabilities of [individuals]...'. Hence, the tacit component of technological knowledge is seen as

encapsulating a different set of communication problems than those which encompass the transfer of codified knowledge. The challenge lies in defining just what these problems are.

Another aspect to the difficulties of developing technological capability is determining what significance should be attached to the particular nature of organisations in this process. Cooper (1994, p. 20) maintains that the concept of "national systems of innovation" represents a potentially a fruitful line for development research. Drawing on the insights of studies of innovation in developed countries, Cooper explains that this approach looks to the environment for explanations as to why divergent paths have been taken by organisations in the learning of their technological capabilities, as well as revealing links between these circumstances and barriers to capability development (pp. 7-9 & 19). The emphasis on tacit knowledge development and the organisation are related to the extent that tacit knowledge is borne out of the experience of interaction with technology *within* the organisation (p. 30). Factors which distinguish organisations, such as their size, their histories, the technologies they use and the routines and knowledge which have been developed in response to these technologies, represent indicators of current and future technological capabilities (pp. 29-30).

The two studies chosen for analysis are broadly analogous to progress in technological capability development theory where increasing significance is devoted to the tacit components of technological knowledge and the environment in the development of technological capability. The first study chosen for analysis, a monograph authored by John Enos (1991) titled, *The Creation of Technological Capability in Developing Countries*, is notable for its central assumption that technology is taken for granted and the environment is '...variable...' (p. 2). The second study, a paper written by Martin Bell and Keith Pavitt (1993) titled 'Technological Accumulation and Industrial Growth: contrasts between developed and developing countries' asserts that there are a number of enduring features in the local environment that are influential in the development of

technological capability. They describe these features in terms of '...national systems of innovation...' (p. 165) and '...differentiated and path-dependent processes of learning...' (p. 202).

The schools of thought to which the studies can be linked represent two major areas of discourse within institutional economics identified by Hodgson (1994). Indeed, Enos (1991, p. 11) identifies himself as an institutional economist but his emphasis on growth modelling is suggestive of a neoclassical emphasis. Hodgson (1994, p. 400-402) classifies this approach as 'new institutionalism' which, he contends, is largely drawn from orthodox neoclassical economic traditions. In contrast to neoclassical economists, however, the primary role Enos (1991, p. 7) bestows on government in coordinating the development of technological capability is at odds with the neoclassical tradition which sees optimal distribution of resources being largely a function of markets. Bell and Pavitt (1993, p. 158), on the other hand, through their identification with Nelson and Winter (1982), stress an evolutionary economic framework, which considers characteristics such as '...disequilibria, uncertainty, learning and inter-firm and inter-country differences...' as important. Hodgson (1994, pp 400-402) explains that Nelson and Winter's perspectives can be associated with the earlier work of both Schumpeter and Veblen, (both of whom stood opposed to neoclassical economic reasoning), and accordingly classifies this area of institutional economics as '...old institutionalism...'.

2.2.2 Study 1: Enos (1991)

The impetus for the work by carried out by John Enos (1991) for the International Labor Organisation (ILO) was the development of a '...systematic framework within which...[the]... evolution of...[technological capability]...in a given country or across countries...be analysed...' (p. xi). The task allotted to Enos (1991) in devising a global system for the analysis of technological capability was formidable. In response to this

challenge, Enos devises two growth models which place considerable emphasis on the investment in education in preference to present day consumption and capital expenditures (pp. 19-55). The factors which Enos promotes as being important in the pursuit of technological capability are the gradual building of national capabilities based on the learning of technical principles imparted in formal education, the establishment of a hierarchy of technical institutions in which knowledge and skills are developed and disseminated, and the imbuement of people with a sense of common purpose (pp. 171-174). His goal is the establishment of a foundational technological capability which, albeit, may be suited to dated technology (by virtue of the channelling of investment to education rather than capital expenditures) but importantly to Enos, represents a viable base from which improved capabilities can develop (pp. 53-55).

Enos defines the nature of his study by casting it as being diametrically opposed to what he characterises as appropriate technology (p. 2). Enos dismisses appropriate technology on the basis of it demanding just as many scarce resources as the absorption of foreign technologies (p. 1). As Enos claims that appropriate technology proponents view technology to be variable and the environment given, his stance is accordingly one of viewing technology as the given element and the environment as being variable (p. 2).

Enos defines technological capability as '...the ability to employ technologies; to absorb the descriptions, to comprehend the explanations and to follow procedures...' (p. 167). He constructs a substantial edifice in his bid to cover the full range of economic activities a developing country might undertake. The areas he identifies as most important are primary production (agriculture), secondary production (mining, manufacturing, communications and engineering support services) and tertiary production (government and educational services) (pp. 57-59). This chapter's discussion is limited to Enos's analysis of the secondary and tertiary sector for the reason that these two sectors are most relevant to the engineers of this study. Enos acknowledges small country problems by his exploration of '...indivisibilities...' and '...market failure...' and argues strongly for

a pro-active role for government in coordinating institutions so as to ameliorate these constraints (pp. 7-8).

Citing support form the literature, he identifies three fundamental components of technological capability - the individual, the institution and the imbuing of common purpose (pp. 9-12). The formulation of his basic '...education cum production...' (p. 43) growth model places a considerable burden on education to fulfil much of the development in these three areas. In terms of instilling individuals with both technical knowledge and common purpose, he asserts that the inculcation of scientific method through basic education as the key to bringing about this transformation (pp. 121-122). Enos states that education in subjects such as maths and science is preferable to subjects such as history and religion because this '...will enable them to associate cause and effect in the physical world in which production takes place, and will help to dispel explanations based upon myth or morality...' (p. 122). His characterisation of technical knowledge as having a strong association with science is the basis on which he argues it can be codified, systemised by a hierarchy of educational and research institutions and thereby efficiently disseminated (pp. 142-146).

The role of the technology-using organisation in this scheme is oriented to the application of technological knowledge. Enos states:

> [t]he institution is the device which permits all the requisite technical knowledge, incorporate in human beings, to be assembled and applied (p. 8).

The characterisation of learning within the organisation is reminiscent of the science laboratory in which '...the firm provides a constant environment within which the evidence can be gathered and experimentation performed, a source of the funds needed for the task, and an institution on which loyalties can be fastened...' (p. 113).

The emphasis Enos places on formal education speaks most directly to the formulation and transfer of codified knowledge and less to the role of experience in this process. While human skill is identified as essential to the use of technology in the secondary sector (pp. 122-123), Enos is vague about the relationship skill has to technological capability or the means by which it is developed, as the following extracts reveal.

> [Technological capability] utilises a complex mix of human skill whose common characteristic is technical knowledge (p. 9).

> All firms with any pretence to being technically efficient devote a considerable portion of their revenue to increasing the skills of their work force (p. 115).

> Improvement in operation, better planning and better procurement and better construction will *tend to emerge* in the course of driving for greater output [italics added] (p. 151).

> As to the relation between capability to perform one task and the capability to perform another, the evidence is scanty...[There is no] guarantee, that once having undertaken a task, the firm will proceed to master it; many are the examples in developing countries of the arrested acquisitions of capabilities. Capability does not necessarily result from an attempt to achieve it (p. 106).

Enos admits that his study is hampered by the paucity of research and, as a consequence, he is able to only describe organisational characteristics which have been found to respectively contribute or detract from achieving technical excellence. The organisation most likely to achieve technical excellence has: '...substantial scale, big enough to employ a complement of engineers, technicians and technically knowledgable managers,...has a relatively large and secure source of income....and is permeated with an *esprit de corps*...' [italics in original] (p. 113). The attributes of the organisation which will

detract from technical excellence reflect the poor attitudes of the owners and staff: '...managers [who] are chiefly interested in amassing wealth, in providing for themselves and their employees a quiet existence, in subsidising a political movement or an ideology, in monopolising their markets...' (p. 113). The reasons why these factors are variously associated with success or failure is never fully explicated by Enos thereby leaving readers to make their own judgements. Such detail is arguably of interest to those who, by reason of small organisational size or limited financial resources, must develop alternative responses in order to account for these deficiencies.

In summary, Enos places significant emphasis on technological knowledge to deliver revolutionary changes to the organisations of developing countries. However, the linkages between the knowledge which is imparted in formal education and its application in the development of experience within the organisation are not supported with any explicit rationale concerning the nature of technology or the organisation. As a consequence, beyond the basic requirements for organisations to be large and have plenty of money, the organisation's role, and the common purpose to which people are expected to adhere, appears as one which is ascribed primarily to the goal of technical excellence.

2.2.3 Study 2: Bell and Pavitt (1993)

The second study of technological capability development analysed is one undertaken by Bell and Pavitt (1993). Bell and Pavitt argue that the increasing complexity of modern technology precludes the derivation of a set of '...best practice...' rules which can adequately describe every possible aspect of its operation (p. 166). In view of the infeasibility of providing documented information to cover all these possibilities, the development of tacit knowledge which is derived by actual experience with the equipment is required. The environments in which this learning occurs emerges as being influential in this learning. Bell and Pavitt however, go on to argue that despite the importance of

experiential learning, learning-by-doing is not enough (p. 170).[1] They argue that the nature of modern technology is such that little is revealed about the internal dynamics of machines and equipment through day to day operation (p. 165).[2] They recommend that specific measures be instituted within organisations to promote experiential learning and the transfer of experiential knowledge through communication. While they support formal education as an important component for capability development, they argue that this should not be the sole emphasis of capability development. Such an emphasis, they maintain, ignores the importance and distinctive nature of learning which must occur within the organisation.

The analysis provided by Bell and Pavitt can be divided into two sections: the first part defines the nature of technological learning in firms from industrialised countries; the second scours the available evidence of developing countries for signs of what they define as technological capability. Of central interest to this chapter is the first part of their analysis which deals with the process of technological accumulation or learning within the organisation which Bell and Pavitt argue as leading to capability development (p. 164). The second part of their analysis is discussed in Chapter 3.

Bell and Pavitt emphasise the concept of technical change as being important to understanding the development of technological capability. From a Schumpeterian perspective, technical change is considered fundamentally important as it is viewed as being the engine for economic growth (Fransman, 1986, p. 3; Nelson and Winter, 1982, pp. 39-40). While this translates into strategies for on-going performance improvement from technologies, Bell and Pavitt also relate the necessity for technical change to a more practical requirement in technology transfer where technologies need to be '...moulded to

[1] Cooper (1994, pp. 30 & 33) and Clark (1985, pp. 191-193) similarly warn that while learning-by-doing may be an analytically convenient concept, it is seriously misleading if observers conclude that this idea describes the totality of processes which contribute to technological learning.

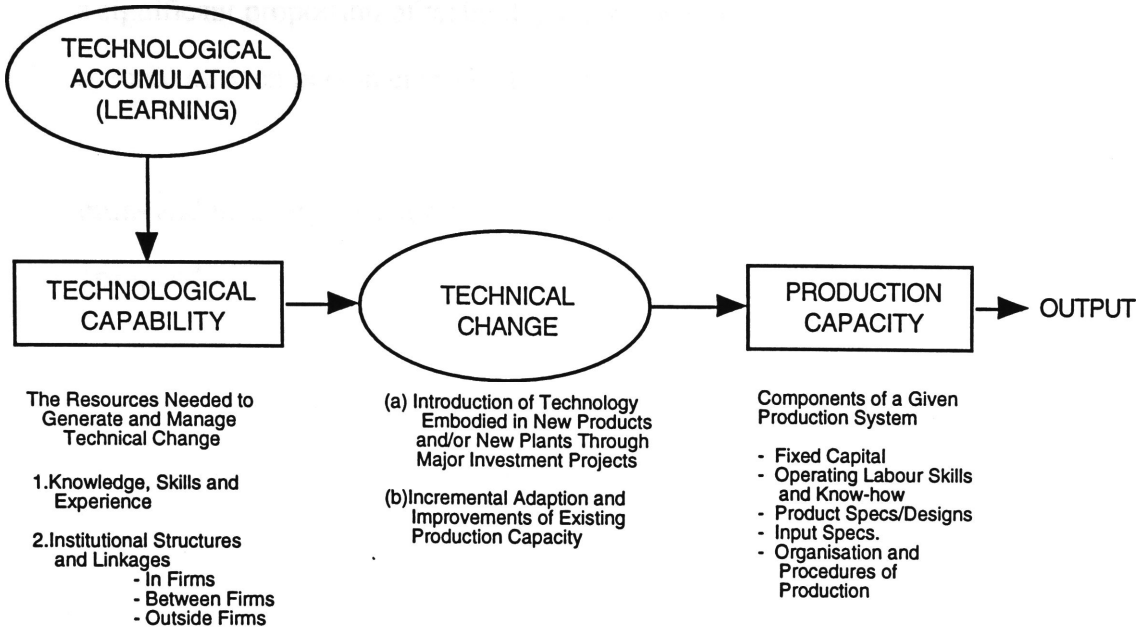
[2] Bell and Pavitt (1993, p. 202) argue that the attributes of technology which inform current economic orthodoxy are drawn from nineteenth century technologies. In contrast to the relative simplicity of nineteenth century technology, Bell and Pavitt maintain that complexity is a characteristics of modern technology and more effort is required to incorporate the particular challenges this poses into modern economic theory.

fit particular conditions of use in a widening range of specific situations...' (p. 160). This leads Bell and Pavitt to question the veracity of a fundamental and popular concept in development studies - the linear innovation and diffusion model (pp. 160-163). As innovation is usually portrayed in this model as being the provenance of institutions in developed countries, the role of developing countries is accordingly restricted to the passivity of merely applying the principles developed elsewhere, in the diffusion phase. Essentially their argument is one which states that developing countries need a capacity for technological creativity not unlike that attributed to developed countries (p. 161).

Bell and Pavitt go on to define technological capability as a capacity to accomplish technical change. The term "technological accumulation" signifies the process of developing technological capability and is interchangeable with the term "technological learning" (p. 163). Importantly, they identify a growing separation between the '...technology-using skills...' of day-to-day production and the '...technology-changing skills...' required to generate and manage technical change in response to the increasing complexity of equipment, machinery and operating processes (p. 165). They explain:

> [w]e therefore distinguish between two stocks of resources: the skills knowledge and institutions that make up a country's capacity to generate and manage change in the industrial technology it uses (i.e. its technological capabilities) and the capital goods, knowledge and labour skills required to produce industrial goods with 'given' technology...By technological accumulation, we mean the accumulation of the first of these stocks of resources (p. 159).

Bell and Pavitt's spell out the sequence leading to better production methods as one which identifies technological accumulation as the precursor to technological capability which in turn provides the means by which technical change is carried out (see Figure 2.1).



Technological Accumulation: Basic concepts and terms

(Source: Bell & Pavitt, 1993, p. 164)

Figure 2.1

They see the root cause of the difficulties associated with accumulating technological capability as being insufficient investment in firm-centred learning aimed at generating and managing technical change. While recognising the role of formal education and training,[3] they identify a number of factors which suggest that formal education is not sufficient in itself for the development of technological capability. Attributes of technological learning which occurs within the organisation identified by Bell and Pavitt are as follows:

> trial error and experience are central to the improvement of technology (p. 166);

[3]For example, Patel and Pavitt's (1994, pp. 21-22) paper on the significance of national systems of innovation as an explanation for different and arrested levels of development between countries correlates educational attainment with productivity levels.

a significant proportion of technological knowledge is uncodified, institution specific or even person embodied (p. 166);

intra- and inter-organisation communication is a feature of dynamic companies (p 168); and

experiential learning, or learning-by-doing, needs to be complemented by specific investments by the organisation to facilitate the development of institution specific knowledge (pp. 169-170).

In comparing this study to the one undertaken by Enos, there are areas of agreement in terms of the importance of both modern technology and the institution. On the other hand there are considerable differences in the underlying rationales supporting the respective measures. Enos presents a study which gives prominence to ensuring optimal input conditions for an idealised growth model intended to promote technological capability. The transformations which occur within this model are based on learning process which rely on scientific-styled endeavour without reference to the circumstances in which organisations reside. In contrast, Bell and Pavitt see this learning process as being much more intertwined with the unique characteristics of individual organisations and countries. They claim, therefore, that technological capability development strategies are reliant on personal engagement with the technology, past learning and communication with others inside and outside the organisation. From Bell and Pavitt's perspective, strategies aimed at promoting technological capability should therefore acknowledge the situated nature of technological capability development.

2.3. KNOWLEDGE DEVELOPMENT IN ENGINEERS

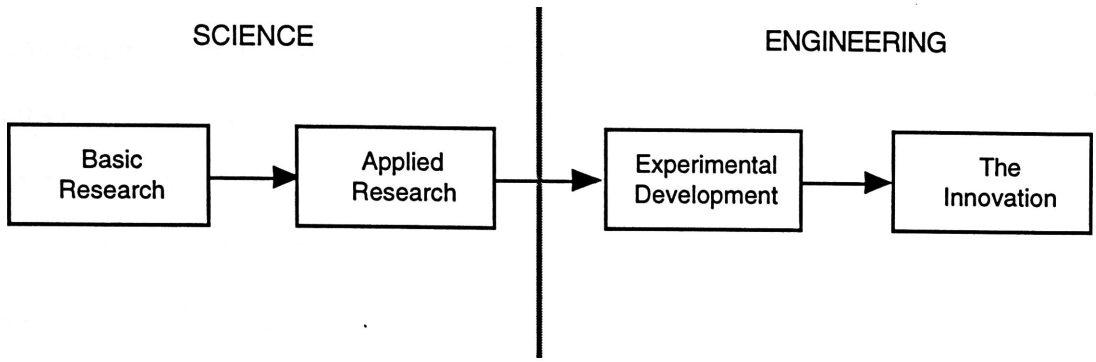
The two studies of technological capability should ideally serve as an overarching framework under which the activities of various occupational groups who use modern technologies in developing countries can be understood. As the engineers of this study represent one such occupational group, attention is now devoted to comparing these two studies of technological capability (Enos, 1991; Bell and Pavitt, 1993) with research into the practice of engineering. Using the major points of division between the two studies determined in the previous analysis as a guide, the purpose of this section is to explore the role of experience in the knowledge development of engineers and the influence the environment has over this process.

2.3.1 The Controversy over Theory and Practice

The great strides in technological development which have come to characterise modern industrialised societies are popularly regarded as the product of a linear relationship between science and engineering (Macdonald, 1998a, pp. 42-46; Johnston et. al., 1995, p. 133). Vannevar Bush, a prominent United States engineer during and after World War II, is credited with articulating this linear relationship which has become the dominant view of modern technology development today (Johnston et. al., 1995, p. 133). Bush described this process in the following way.

> Basic (pure) research leads to new knowledge. It provides scientific capital from which the practical applications of knowledge must be drawn. New products and processes are founded on new principles and new conceptions which in turn are painstakingly developed by research in the purest realms of science (cited in Johnston et. al., 1995, p. 133).

Science is perceived as the font from which the laws of nature are taken and then pressed into action within the machines and equipment engineers design (see Figure 2.2).



Linear Model of Innovation.

(Adapted from: Johnston et. al., 1995, p. 135)

Figure 2.2

Interestingly, the tension identified previously by Bell and Pavitt over the explanatory value of the linear model of innovation and diffusion is a feature of the debate over the nature of technological knowledge development in engineers. Mitcham (1995, pp. 13-14) argues that this view of engineering represents only one perspective on modern day engineering and suggests that this approach has served to mask other important aspects of engineering, most particularly, its social role. The other dominant strand of discourse on engineering Mitcham identifies is one which views the practice of engineering in a broader historical and cultural context. The issue which distinguishes these alternative approaches centres on the relative significance which is accorded to theory, on the one hand, and practice on the other. Discourse among those who attest to a unidirectional alignment between science and technology argue that practice is derived from theory. The later argue that practice represents an activity which historically has preceded theory development.

The most active advocate of the science-engineering alliance identified by Mitcham (1994, p. 197) is Mario Bunge. To Bunge, technology is the '...scientific study of the artificial...or the field of knowledge concerned with designing artefacts and planning their realisation, operation, adjustment, maintenance and monitoring in the light of scientific knowledge...' (cited in Mitcham, 1994, p. 197). Engineering practice and technics (craft skills) are distinguished from knowledge on the basis that they represent activities. The key factor distinguishing these two forms of activity is that engineering practice is derived from, and is subservient to, theory, while technics is considered as a pseudo-technology, in much the same way astrology is viewed as a pseudo-science. Bunge explains that the key issue, is the '...process whereby crafts are given a technological basis, and...converted into applied science...' (cited in Mitcham, 1994, p. 197). Underlying this philosophy is the belief that all natural things, including human endeavour and skill, are potentially amenable for codification into theory.

Within the context of Bunge's explanations, the lack of detail Enos provides regarding the development of skill and its relationships to theoretical knowledge is better understood. As this view holds that practice is derived from theory, the inculcation of theoretical knowledge assures that practice will inevitably follow. Additionally, the hierarchy of research and educational institutions Enos recommends also makes sense from Bunge's perspective. The method of determining the relative status of qualifications from institutions is logically one based on the relative complexity of scientific and mathematical theory. (For the Australian case, see Johnston et. al., 1995, p. 465; for the United States, see Kemper, 1993, pp. 107-110). The primacy of theory over practice is apparent in Kemper's (1993, p. 110) description of engineering design, where the role of the engineer is to generate the intellectual content for the craftsman to '...physically embody the engineers' designs...' into artefacts.

Interestingly, Kemper (1993, p. 110) proceeds to outline an important role for the craftsman as the person who discovers '...the engineers' mistakes...'. Rather than a

mistake, the discovery of deficiencies of theory when integrating artefacts into real world contexts is argued by some commentators as revealing the fundamental role of practice in the development of knowledge within engineering. From this perspective, Kemper's commentary reveals a limitation of theory to account for all real-world factors. Experience emerges from Kemper's descriptions as a potentially important aspect of knowledge development for engineers.

Empirical studies of engineers working at the technological frontier (Staudenmaier, 1985; Constant, 1984), an activity one could reasonably expect to be dominated by science, reveal a number of significant differences between science and engineering which question the linear associations between science and technology. In a study of articles published in the science and technology journal, *Technology and Culture*, Staudenmaier (1985, pp. 105-107) finds that the easy passage of ideas from science to engineering is precluded by his finding that science and engineering are motivated by different goals. Staudenmaier argues that technological knowledge is aimed at contending with the functional design of artefacts within the constraints of specific contexts. Staudenmaier calls this "ambience", which refers to a broad set of contextual elements such as history, economic constraints, cultural values and institutions (pp. 173-174). Scientific knowledge, he contends, is more concerned with the abstract goals of theory and nature (p. 89). While his intention is not to deny that science plays a part in the development of sophisticated technologies, Staudenmaier asserts that the contribution is usually at a high level of abstraction requiring a significant degree of adaptation by engineers (p. 105).

Constant (1984) makes a similar assessment, arguing that technology and science have a different '...locus of ambiguity...' (p. 35). He observes that while disagreement between scientific disciplines is unlikely to cause crisis, ambiguities in the design process of sophisticated technologies threaten total system performance and therefore, cannot be tolerated (pp. 35-37). In response, he argues that engineers take '...epistemological liberties usually denied science...' such as drawing on empirically derived information

about how materials perform in the real-world (p. 35). Examples cited range from over-design, that is '...[i]f it breaks, make it bigger...' to methodologies such as the use of '...parameter variation or dimensional analysis...' which he argues '...suffer no intrinsic embarrassment before more orthodox '..."hypothetico-deductive" methods...' (p. 35). The point which emerges as most significant from Staudenmaier's (1985) and Constant's (1984) observations, is that the goals of engineering are oriented more to the practical and pragmatic, where the contesting constraints of available materials, poor understanding, time, or society need to be resolved in order to ensure technological objects function within their particular environments.

This leads both Staudenmaier (1985) and Constant (1984) to the conclusion that the evidence does not support the central contention of the linear model of innovation which claims that technological knowledge is the mere application of science. Mitcham (1995, p. 198) agrees.

> The problems of science are cognitive ones solved by observations that result in the accumulation of information about the world. Science aims at understanding, and its central element is scientific law that purports to describe the way the world is. The problems of technology, by contrast, are practical. Technology aims at control, and its central element is a rule (sometimes called a law) that purports to prescribe the way the world can be manipulated.

The real world contexts in which engineers work is therefore argued by these commentators (Staudenmaier, 1985; Constant, 1984; Mitcham, 1995) to be of significance if one is to come to a meaningful understanding of the capabilities engineers are required to possess. At issue are the factors of the physical and social environment which influence the development of technological knowledge in engineers. The following discussion aims to better define the relationship between two significant

elements of the engineers world, the technological artefact and the organisation, and the development of technological knowledge.

2.3.2 Engineering in Context - the Machine

The following discussion argues that a major factor determining the nature of technological knowledge is the enigma-like nature of machines and equipment. While acknowledging that the purpose of the machine is to ensure a degree of certainty, it is argued that there are many characteristics of the machine which are under-determined and hence, not amenable to codification. Staudenmaier (1985, p. 107) asserts:

> [no] technology is ever completely understood, even after it has been introduced into normal practice. Technological knowledge is only a partial understanding of the characteristics of the real-life artefacts and processes.

Staudenmaier argues that two bodies of technological knowledge exist to mediate the resolution of machine problems - theory and technical skill (pp. 119-120). He characterises theory as having no direct association with problems which occur with artefacts in the field (pp. 110-111). Rather, he ascribes theory with the purpose of describing new concepts and defining particular attributes of problematic data - problematic data being the information which answers a particular question about the operation of the artefact.

Technical skill, on the other hand, represents a form of knowledge which is distinct from theory in that it is derived from the experience of dealing with actual problems in the field (pp. 114-120). Descriptions of engineering skill fall into two categories: firstly, the '...learned intimacy with particular tools and machines...' and secondly, the experience

which is accumulated allowing '...technical judgements...[to be made]...which cannot be reduced to purely theoretical knowledge...' (p. 115). Staudenmaier asserts that engineering skill is irreducibly distinct from engineering theory disputing the linear association of Bunge, that of engineering skill being the application of engineering theory (p. 120). Interestingly, Staudenmaier characterises theory as akin to a language (p. 110). Within this framework, the primary goal of technical schools and journals is to foster the learning of such language so communication among practitioners about problematic data can take place.

This focus on the localised nature of problem solving is echoed by Forsythe (1993, p. 453) who argues that theoretical knowledge is not self evident but needs to be interpreted locally to achieve meaning. Forsythe describes the engineers of her study as belonging to a particular cultural group on the basis that '...[t]he values and beliefs shared within a group constitute part of what anthropologists call culture...' (p. 448). Forsythe asserts that culture defines what we take for granted and identifies '...tacit values and assumptions...., and the common sense truths that everybody knows within a given setting...' as underlying the comprehension of formal truths in theoretical knowledge (pp. 448 & 449). The utility of theoretical knowledge, from Forsythe's perspective, is therefore largely determined by a shared understanding among groups of people, which she calls "tacit knowledge". The identification of culture by Forsythe portrays engineering as a pursuit influenced by the same uncertainties as other areas of social activity in which communication plays an instrumental role.

Orr's (1996) study of photocopy technicians is particularly relevant here as it deals with technicians working some distance from the technological frontier. Orr describes the photocopy technicians of his study as belonging to a '...community of technicians...' and is effective in revealing the importance of story telling in ensuring this community is able to collectively respond to the uncertain nature of photocopy machines (p. 2 & 125-143). It was found that there are many "yet-to-be" discovered truths about the machine even

though these practitioners have access to a full set of documentation and trouble shooting procedures (pp. 105-113). Orr states:

> [t]echnicians practice is therefore a response to the fragility of available understandings of the problematic situation...[and]...to the fragility of control over their definition and resolution (p. 2).

Furthermore, Orr maintains:

> [w]ork in such circumstances is resistant to rationalisation, since the expertise vital to such contingent and extemporaneous practice cannot be easily codified (p. 2).

Orr's commentary suggests that experiential knowledge development and communication through story telling represents a necessary response to achieving coherency in uncertain situations. The apparently ad hoc combination of codified and tacit knowledge through story telling appears in response to the uncertain nature of the machine's condition. While hypothetically it may be correct to state these varied pieces of information fit together in a coherent way, (by virtue of the fact that the machine once did work), achieving this coherency is a difficult task when the machine is broken.

Echoing Forsythe's (1993) interpretation, Orr views the interaction between his technicians as constituting a distinct culture within the organisation (pp. 12 & 140-142). Orr maintains that the stories the technicians tell contribute in important ways to developing their sense of community as well as serving as a repository for the group's knowledge (pp. 11-13 & pp. 126-127). For example, he notes that the stories often appear as unintelligible to outsiders in that the technicians often omit details (p. 12). Orr argues that these missing details serve to circumscribe the technicians as a group in that

competent members are expected to know these details by virtue of their common knowledge.

These studies provide a number of windows to the development of technological knowledge in engineers which reveal experience and communication playing an instrumental role in the resolution of machine problems. In promoting a more functional and distinct role for knowledge derived from experience, the need for interpersonal communication emerges as an efficient means by which this knowledge can be transferred. In exploring the influence of the machine on the characteristics of technological knowledge development, the preceding discussion argues strongly in favour of the emphasis given by Bell and Pavitt (1993) to the experientially based aspects of technological knowledge. The engineering studies assert that there are many "yet-to-be" discovered truths about the machine which requires a knowledge base generated through close engagement with the machine and communication with other experienced practitioners. Therefore, tacit knowledge development through experience and communication appears as an critical aspect of technological capability development in engineers. In contrast, the explanation that Enos (1991, p. 151) advances that skill development is something which '...tends to emerge in the course of driving for greater output...' appears as an inadequate response within the context of these studies of engineers.

2.3.3 Engineering in Context - the Organisation

The other dominant contextual element studies of engineers reveal as being important is the organisation. Studies by Noble (1977), Whalley (1986) and Orr (1996) are examined in order to reveal two significant factors regarding the relationship between the engineer and organisation. Firstly, these studies reveal that the experience of many engineers is

one where they are bound to serving their organisation and submitting themselves to the role the organisation performs in the broader community. Secondly, it is found that the organisation plays an important role in facilitating the problem solving endeavours of the engineer.

Noble's (1977) study of American engineers represents one major work which dispels the notion that the engineers' work is solely ascribed by the non-ideological pursuit of discovering and applying scientific theory. Rather, Noble argues that the organisation's function within capitalism subsumes the role of engineers as an integral part of the capitalist hegemony. As Noble puts it,

> [t]he technical and capitalist aspects of the engineer's work were the reverse sides of the same coin, modern technology. As such, they were rarely if ever distinguishable: technical demands defined the capitalist possibilities, only insofar as capitalist demands defined the technical possibilities (p. 34).

Whalley's (1986) study of British engineers provides support for the general thrust of Noble's argument. The role he ascribes to theoretical knowledge is one which indicates a basic capability by which employers are able to assess suitability of individuals for employment (pp. 53-58). Once in employment, Whalley contends that the importance of theoretical knowledge becomes more diffuse where the employer has more immediate authority over these individuals to determine the value of particular forms of knowledge. (p. 65)

Whalley notes however, that Noble's (1977) critique doesn't explain the emergence of divergent forms of engineering organisation which have developed in different countries of the industrialised world. Whalley states:

> [there is no] 'logic of production' or a 'logic of capitalist accumulation' which provides 'one best way' of organising production. Although an occupation to carry out *discretionary tasks* exists in all industrial capitalist societies [italics added] (p. 186).

Citing examples from Britain, France and the United States, Whalley argues that different forms of engineering organisation have emerged in response to the particular histories which characterise these countries (pp. 185-191). While acknowledging that these processes are unique to each location, he argues that it is indeed social process which is the impetus for these differing forms of organisation (p. 1). The extent to which these contexts may vary and be unique explains the different manifestations of engineering organisation displayed in these countries.

Also identified within the above citation is the central place Whalley gives to "discretionary tasks" within the practice of engineering. Whalley argues that employers are required to extend to engineers trust to carry out these discretionary tasks associated with the organisation's capital equipment (pp. 58-64). Though not specifically stated by Whalley, in the light of studies by Staudenmaier (1985), Constant (1984) and Orr (1996), the necessity of these discretionary tasks appears as a reflection of the uncertain nature of the machines and equipment engineers must work with.[4]

The social orientation of the technician's work in Orr's (1996) study is expressed in terms of the need to resolve the ambiguity of a broken machine in the client's premises - the ambiguity arising from the legal contract the technician's employer has to its clients (p. 109). Hence, the client, the organisation and the service team, linked together by the photo copier machine, represent a set of relations which come under threat when the machine breaks down - a task the service technicians endeavour to resolve (p. 3). It is

[4] Whalley (1986, p. 19) remarks that he would have liked to have spent more time becoming better acquainted with the technical issues the engineers of his study were grappling with. One wonders whether he would have detailed a more instrumental role for the artefact in his explanations of technological knowledge if he had done so.

noteworthy that the development of the technician's knowledge in Orr's study is ultimately in response to the need to resolve tension in the relationship between organisation and client, whether it is of a machine nature or the demands of an unreasonable client (pp. 78-88). Knowledge development occurs in the context of crisis in which both the machine and the client's response represent unpredictable elements in this exchange. Order and systematic behaviour are ostensibly used by the technicians as a hedge against the uncertainty of the machine but ultimately ensures that the relationship with the client is also kept in check (p. 128).

Orr portrays the organisation as a place which not only provides the technicians with their social purpose but is also the place which facilitates their ongoing knowledge development. Orr maintains that learning is an organisation-situated process in which the workplace has supplanted the school (p. 56). The organisation is thus seen as influencing the knowledge development of these technicians in a number of ways. The fact that the members have developed expertise in the repair of certain models of photocopy machines is one obvious example. The organisation assists in providing training, tools and presumably transport for the technician to travel from location to location. The equipment documentation is valued for the interconnection documentation rather than the directives associated with fault repair. Here the organisation plays a curious role in thinking that the fault direction documentation that it provides is incisive in the engineers work while in reality the organisation's most notable accomplishment is one which gives the technicians the freedom to enable them to work and communicate in a cooperative manner (Orr, 1996, p. 140).

The ability to undertake discretionary tasks, extending trust and the freedom to informally communicate, emerge from Whalley's (1986) and Orr's (1996) descriptions as important contributions the organisation makes in assisting the engineer apply and create knowledge within the context of the organisation. Along with Noble's (1977) study, these two studies also maintain that the social purpose that the organisation is orientated to is

important in directing the engineers work. The response the two studies on technological capability (Enos, 1991; Bell & Pavitt, 1993) make on these two counts is therefore important in assessing their suitability for capability development in engineers.

Bell and Pavitt's approach of associating the tacit knowledge development with the unique influence of differing contexts, a relationship they argue is mandated by the complexity of modern technology, resonates with the observations contained within the studies of engineers described in this chapter. It is difficult to perceive the same degree of engagement between the organisation, its employees and technology in the study by Enos. The ambivalence Enos displays to experience and its relationship to technological knowledge is revealed to be a weakness within the context of these studies of engineers, particularly as it relates to his ideas on the organisation. The use of mechanistic analogies, such as '...device....' (p. 8) to describe the organisation along with its detachment from the broader community conjures up notions of the rarefied environment of the science laboratory rather than one which is actively engaged in a broader society-wide project.

In terms of the role the organisation plays in facilitating the work of its employees, neither Enos nor Bell and Pavitt explicitly identify trust and freedom as necessary ingredients to enable technological capability development. Nonetheless, the elevation of problem solving by Bell and Pavitt as a legitimate knowledge creation activity and, quite separate to that which is taught in educational and training institutions, is supported by the studies of engineers. The advice given by Bell and Pavitt that organisations must invest in the creation of tacit knowledge by encouraging the transfer of experiential knowledge through initiatives such as the establishment of intra- and inter-organisation links is supported by studies which reveal an instrumental role for communication in this transfer process. The organisation is viewed by Bell and Pavitt as possessing capabilities accumulated over time where past history is viewed as a determinate of future knowledge acquisition. As detailed earlier, Enos does identify the organisation as being important in the development

of skills but does not provide an explicit rationale through which readers are able to gain an understanding of the processes which contribute to skill development.

The studies of engineers also provide a more detailed understanding of the significance the social goals which organisations possess has over the work of engineers. As stated in this chapter's introduction, the two studies of technological capability are orientated to the goal of economic growth. The implications of such a focus on Pacific Island engineers and organisations is discussed in Chapter 3.

In summary, Enos's study generally stands apart from Bell and Pavitt's study in failing to draw more specific links with the complex nature of modern technology and the processes leading towards skill development and the influence of real world contexts over these processes. From this perspective, Bell and Pavitt's study makes more penetrating inroads into the question of technological capability development for engineers.

2.4. TECHNOLOGICAL CAPABILITY DEVELOPMENT IN ENGINEERS

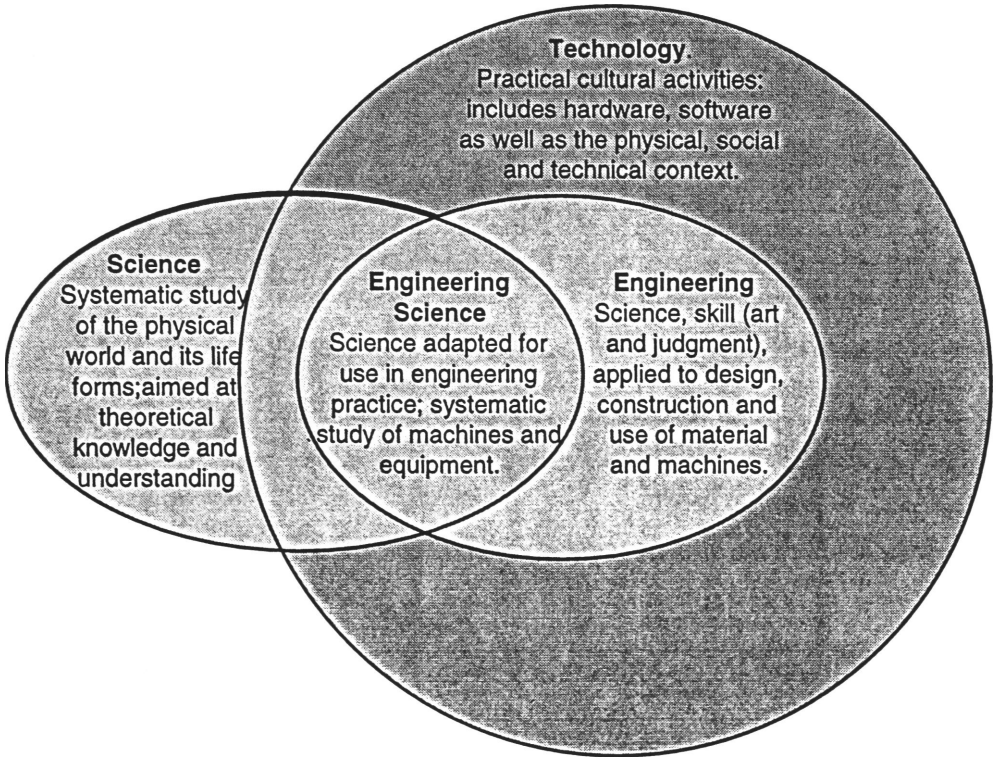
The analysis within this chapter has demonstrated that a fundamental requirement for technological capability development theory is to recognise the need of engineers to undertake experiential knowledge development in order to account for aspects of the machine's operation which are not detailed in codified information sources. The authority the organisation has over the engineers they employ distinguishes the organisation as being an influential determinate of technological knowledge development in two ways: firstly, the organisation provides the engineers with the social purpose to which their efforts are directed; and secondly the organisation is important in facilitating problem solving by providing the engineers with the necessary resources to undertake these tasks. Therefore, the process of technological knowledge development in engineers is one

which is significantly determined by both the technological artefacts they work upon and well as the organisation they work within.

The studies of engineers cited in this chapter attest to the distinct character of engineering which stands apart from scientific endeavour. This finding calls into question the adequacy of recommendations made by Enos for the development of technological capability in engineers of developing countries. The confidence which Enos (1991) places in theoretical knowledge to deliver technologically capable practitioners reflects the linear association both Bush (cited in Johnstone et. al., 1995, p. 133) and Bunge (cited in Mitcham, 1995, p.197) embrace. The use of growth modelling, the presumed sufficiency of theoretical knowledge and the limited goal of technical excellence which he ascribes for the organisation combine to exclude the influence of real world environments. As engineers are required to respond to these contingencies, failure to account for this basic reality of the engineer logically represents but a partial understanding of technological capability development for engineers.

In contrast, the concern Bell and Pavitt (1993) exhibit in relation to the enduring qualities of different social and physical contexts finds support in the studies of engineers cited in this chapter (Constant, 1984; Mitcham, 1995; Noble, 1977; Orr, 1996; Staudenmaier, 1985; Whalley, 1986). Figure 2.3 summarises the basic thrust of these arguments and is designed to illustrate the interactive relationships between engineering and the broader social and physical context in which it takes place[5]. The experiential learning which is derived from close engagement with technological artefacts distinguishes experience as an important knowledge creating activity for engineers. The importance Bell and Pavitt attach to this experiential learning distinguishes their study as more suitable for technological capability development for engineers.

[5] The role of science in figure 2.3 is portrayed as being similarly effected by these broader contextual influences. Mitcham (1995, pp. 204 & 207) proposes an argument which attributes science with a character akin to technology. In short, he argues that science is predisposed to looking for and measuring data which is pre-determined both by existing theoretical frameworks and measuring instruments (which, because of their technological nature, suffer from the same constraints of materials, existing knowledge and so on). Mitcham argues that science and technology thus share a bi-directional relationship.



Engineering Grounded in a Social Context

(Adapted from: Johnston et. al., 1995, p. 417)

Figure 2.3

While acknowledging the uncertainties regarding the relationships between codified and tacit aspects of technological knowledge, Table 2.1 has been formulated to summarise the characteristics of technological knowledge detailed in the studies cited in this chapter. The table uses the attributes of technological knowledge summarised by Turpin et. al. (1995, p. 64) as the primary attributes under which the examples cited in this chapter are placed. Forsythe's (1993) and Orr's (1996) view of engineering as a distinct cultural activity (one of shared values, assumptions and truths) as well as Staudenmaier's (1985) descriptions of skill are incorporated under tacit knowledge. Also in the light of Orr's (1996) study, both codified and tacit organisation-specific knowledge has been also been included.

Knowledge Form	Attribute (Turpin et. al., 1995)	Examples
Codified technological knowledge (Embodied in artefacts such as machines, equipment, texts, manuals)	Machines and Equipment literature processes .	Machines and equipment engineering theory, specifications of equipment function operating instructions, maintenance procedures Organisational procedures
Tacit technological knowledge (Embodied in people and their skills)	Technical know-how, Experience in solving complex problems	Shared understanding of values, truths, assumptions. Ability to make judgements which cannot be reduced to theory Intimacy with using tools and machines Organisation-specific (local) knowledge

Codified-Tacit Knowledge Profile

Table 2.1

2.5. CONCLUSION

In making an assessment as to which study of technological capability represents the preferred model for capability development for engineers, the discussion argues in favour of Bell and Pavitt's (1993). In citing empirical studies of engineers, it was found that two important contextual features of the engineer's environment were influential in

technological knowledge development - the technological artefact and the organisation. The engineering studies argue that the unknown qualities of the machine require an ability to discover and learn facts about the machine which were not contained in the codified information which accompanies the machine. The identification of interpersonal communication in this localised knowledge development process reveals a particular role for the organisation in facilitating this process. The chapter maintains that the advice Enos delivers is not so much incorrect but insufficient. By relying on a complex structure of technical institutions based on models common in western countries, he fails to fully explore another important aspect of technological knowledge development - the learning which occurs through experience within the organisation. Bell and Pavitt's association between the uncertainties in situating technology in a local context, experiential knowledge development and communication accordingly identifies their study as being the most appropriate model by which to promote the capability development of engineers.

This chapter leaves two issues for further consideration. While tacit knowledge development has been identified as important for the practice of engineering the ambiguous relationship this knowledge form shares with codified knowledge represents a difficulty in prescribing strategies designed to enhance capability development in Pacific Island engineers. This issue is revisited in Chapter 4.

Another question arising from the analysis in this chapter is the influence that the attributes of organisations in the Pacific region are likely to exert on technological capability development. As the organisation is identified as an influential determinate of technological knowledge development, a clearer understanding of the factors motivating the adoption of modern technologies and the consequent establishment of organisations to use these technologies is important and is the subject of the next chapter, Chapter 3.

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Chapter 3

Engineers In Pacific Island Development

3.1 INTRODUCTION

This chapter is aimed at developing a deeper understanding of the processes which constitute the adoption of modern technologies within the Pacific region. The significance of these factors stems from an interest in the organisation, which represents the context into which many of these technologies are situated. The organisation's part in facilitating the process of technological change has implications for understanding not only the social purpose of Pacific Island engineers, but also issues relating to their knowledge development. The three themes of "smallness", "isolation" and "resistance to change" are drawn from the literature (Higgins, 1994, pp. 32 & 37) to act as "touchstones" by which the analysis is able to relate theory to the circumstances of the Pacific region. Two significant issues emerge from this discussion. Firstly, following on from Chapter 2, the existence of small and isolated organisations has significant implications for the transfer of technological knowledge among engineers, particularly as it relates to experientially-derived tacit knowledge. Secondly, the theme of "resistance to change" alludes to the controversies surrounding the consequences of modern technology deployment to local culture. As the two studies on technological capability by Enos (1991) and Bell and Pavitt (1993) are found to only partially account for these factors which are specific to the Pacific region, the chapter identifies a need for further attention to the theory of technological capability development as it pertains to Pacific Island engineers.

In looking to the literature of Pacific Island development, it becomes apparent that the commentary on technology diffusion in the region is marked by its diverse range of perspectives. In response to this, the analysis is undertaken using a theoretical framework provided by Veramu (1998b, pp. 48-49), who identifies three major areas of discourse informing Pacific Island development: modernisation, dependency theory and appropriate technology. The discussion initially determines that the studies by Enos (1991) and Bell and Pavitt (1993) are most representative of modernisation discourse. Critiques of modernisation by commentators of Pacific Island development argue that such strategies have served to deny autonomy in the setting of domestic policy thereby contributing to resistance to the adoption of foreign technologies. The discussion argues that the alternative of appropriate technology is problematic because a fundamental disagreement emerges between indigenous and western proponents over the leverage local culture has in this process of technological change.

In order to later relate these competing issues to the Pacific Island engineers of this study, three portrayals of the "quintessential" engineer of the Pacific are attempted. These alternative portrayals are formulated on the basis of the differing social role implied for organisations and their employees within each of these areas of discourse. They are identified by the descriptions "Cadres of Modernisation", "Pawns of a Global Hegemony" and "Part of the Pacific Way".

3.2 THE MODERNISATION THESIS

The two studies by Enos (1991) and Bell and Pavitt (1993), while notable for providing alternative models for the development of technological capability, can be viewed as two examples of modernisation discourse. Basic to both studies is the accomplishment of social and economic change through the use of modern technology developed in

industrialised countries. Enos (1991, pp. 1-2) cites the demand for latest techniques by '...rulers...' in developing countries as the reason economists have '...shifted their attention to creating, within developing countries themselves, the potential to absorb, even perhaps to generate, modern technologies...'. Bell and Pavitt (1993, p. 163) admit to being primarily interested in the '...dynamics of industrialisation...' and centre their attention on the diffusion of '...high productivity technologies...' in developing countries. The two studies are therefore interesting in revealing the underlying social processes which constitute "development" within modernisation discourse.

The modernisation thesis provides a rationale for development which views the industrialisation of western countries as a model to which all societies should aspire (Clark, 1985, p. 164-169). As Kerr et. al. (1973, p.29, cited in Badham, 1984, p. 26) states:

> The world is entering a new age - the age of total industrialisation. Some countries are far along the road; many are just beginning the journey. But everywhere, at a faster or slower pace, the peoples of the world are on the march towards industrialism.

The economist Rostow is best known for articulating this process of social transformation in his staged model of development which begins with '...Traditional Society...' and ends with '...The Age of Mass Consumption...' (Clark, 1985, pp 165-166). The process of industrialisation is therefore viewed as a higher form of social development largely based on the principle that the knowledge derived from western science represents a more advanced state of cognition (Badham, 1984, p. 75). In contrast, societies which have not undergone this particular form of social transformation are described as traditional, pre-industrialised, primitive or pre-modern; effectively classifying the variety of world cultures on the basis of a dichotomy determined by the use or non-use of western science and technology.

The term "development" embodies the very essence of the modernisation thesis where the progression from a "lower" state of social organisation based on traditional methods to a "higher" level based on western forms of science and organisation is encouraged and directed (Jary et. al, 1995, p. 421). As traditional forms of social organisation are viewed as being incapable of realising their full economic potential, this provides justification for their replacement with western forms of social organisation through a raft a development measures such as the promotion of science, the delivery of western education and the transfer of technological artefacts (Badham, 1984, p. 4; Jary et. al, 1995, p. 421; Shrum et. al., 1995, p. 632). Essentially, the initiatives amount to the creation of western institutional forms in non-industrialised countries, a process which is described by the term "isomorphism" (Shrum et. al., 1995, p. 631).

A number of examples can be cited from the study by Enos (1991) which link it with the modernisation thesis. Enos creates a dichotomy between what he perceives as the dominant values in developing countries and that of the goal of technical excellence creating an impression that existing social structures in developing countries are unsuitable. For example, Enos (1991, p. 151) makes sweeping statements about the adequacy of existing administrations.

> [I]n the majority of developing countries the regular bureaucracies lack the necessary technical skill and discipline. New organisations are required.

Elsewhere, Enos (1991, p. 164) berates individuals in developing countries for not ensuring technical information is shared freely.

> The barriers caused by the deliberate withholding of information in order to enhance the power of the withholder...[w]ould that this were not a common state

of affairs in developing countries! But it is, and should be acknowledged to be so.

The social circumstances in developing countries are portrayed by Enos (1991, p. 175) largely in terms of '...adverse bureaucrats,...remote wealthy landowners and monopolists or hostile ministers...' who are depicted as being essentially opposed to the aims he associates with technical excellence. The basis on which he is able to caste the diversity of cultures and circumstances in such narrow and negative terms is never explicated.

In replacing local values and institutions, Enos perceives a role for technical knowledge which is broader than merely being proficient at using a particular technology but views technical knowledge as a countervailing example to all the "deficiencies" he perceives in developing countries. For example, Enos (1991, p. 122) recommends that the inculcation of scientific method in primary school will '...help to dispel explanations based upon myth or morality...'. He cites factors such as '...amassing wealth, desiring a quiet existence, supporting political movements or ideologies...' (p. 113) as being incompatible with the goal of achieving technical excellence. One wonders how organisations in developed countries have managed to overcome these foibles, or is Enos suggesting these "problems" are only apparent in developing countries?

The work of Badham (1984) in analysing industrialisation discourse provides one possible explanation of the tacit assumptions underpinning Enos's confidence in technical knowledge. Badham (1984, pp 83-88) describes the underlying rationale supporting much industrialisation discourse as being one in which scientific knowledge is viewed as being free from ideology on the basis that it is inherently rational. The pursuit of scientific knowledge is therefore equated with the development of reason. The development of technology from this perspective essentially represents a logical extension to the discovery of scientific knowledge which, because of its special claim to rationality,

is therefore seen as a natural and inevitable consequence of science. In much the same way that criticisms in Chapter 2 were directed at Enos for his inattention to the relationships between theory and practice, he similarly makes little attempt to justify the distinctions he draws between the values of developing countries and technical excellence. Myth, morality or ideology have little place in the technologically capable organisation Enos perceives, the antidote of which appears as a good dose of scientific method at school.

In contrast, establishing links between the modernisation thesis and the study by Bell and Pavitt (1993) is less straightforward. Rather than one path to development, Bell and Pavitt (1993, pp. 177-185) contend that there are many paths to development. From this perspective, they have much in common with commentators who point to the alternative routes to industrialisation taken by nations such as Japan, the United States and those in western Europe and associate this with both the geographic and social circumstances pertaining to these localities (Badham, 1984, p. 3; Clark, 1985, pp. 169 & 173; Nelson, 1993). Another feature of Bell and Pavitt's analysis which can be contrasted to the descriptions of the modernisation thesis earlier is their assertions concerning the tenuous links between science and technology. They argue that the bulk of technological activity in developed countries is between technology-using organisations, who have a common interest in related areas of production, rather than with scientific research and development institutions (Bell & Pavitt, 1993, pp. 166 & 174-175).

However, Badham (1984) explains that adherence to a belief which asserts industrialisation as a natural and central principle on which to organise society is not limited to interpretations of a dichotomous nature, as demonstrated in Enos's (1991) study. Badham (1984, pp. 11-12) also argues that the use of evolutionary metaphors has historically been a competing theme of progress. Within this reasoning, human society is viewed as moving from infancy to maturity in an organic rather than a mechanistic way through the use of western technology. This is most clearly seen in the underlying theory

supporting Bell and Pavitt's analysis which views the routines of organisation as being akin to the entity of a living gene which are orientated to the task of profit maximisation and achieving competitive advantage through technical change (Nelson & Winter, 1982, pp. 14-21 & 96-136; Fransman, 1986, p. 3; Hodgson, 1994, pp. 399-401). Hence, the use of productivity growth by Bell and Pavitt (1993, pp. 186-189) as the basis by which relative levels of capability development are assessed demonstrates a basic belief in economic growth as a desirable and elementary social goal. Therefore, despite the factors which separate the two studies by Enos (1991) and Bell and Pavitt (1993), implicit to both are the underlying principles that western technology represents the most preferable medium for social development and the basis by which relative performance is judged is economic efficiency. As both principles are central to the discourse of modernisation, Badham would probably argue that the two studies represent good examples of how imprecise the theoretical principles which explain the nature of industrialised societies (See Badham, 1984, pp. 88-94). It follows then, that if uncertainty surrounds the theory purporting to explain the emergence of developed countries, doubt similarly emerges as to the utility of these principles in the formulation of strategies for developing countries.

3.2.1 Engineers: Cadres Of Modernisation?

The role and purpose of engineers within modernisation is seen by the specific attention both studies on technological capability (Enos, 1991; Bell & Pavitt, 1993) give to engineers. For example, in citing statistics from companies operating in both India and the Republic of Korea, Enos (1991, pp. 85-86) concludes that the most successful firms were those who had the highest ratio of engineers compared to total staff. Bell and Pavitt (1993, p. 190) note that Korea's success was based on the initial establishment of an '...engineering capability...'. It is clear that both studies perceive a foundational role for engineers in the development of a country's technological capability.

In associating the role engineers have in maintaining modern technology and the broader social purpose to which this technology is used, it can be seen that engineers represent a profession which is on the vanguard of change. It is perhaps of little surprise that Enos attaches greater significance to the role of the engineer than merely maintaining capital infrastructure. For example, Enos (1991, p. 87) argues that engineers are most qualified to engender technological capability in organisations, noting that lawyers, accountants, politicians, civil servants and military officers will probably have inclinations averse to the goal of technical excellence. The knowledge engineers' possess is accorded greater significance by Enos as it is identified as providing the seed from which a new and rational mind-set within the organisation will be extended throughout society. From this perspective, engineers are interpreted here as the "cadres" by which this social process of modernisation is facilitated.

3.2.2 The Problems of "Smallness", "Isolation" and "Resistance to Change"

Badham (1984, pp. 88-90) asserts that the science-technology dynamic in main stream thought has blinded many commentators to the possibility that industrialisation may not be the inevitable end-point to which all societies must aspire. The accuracy of this assertion is no more apparent than when taking a closer look at the Pacific in which many practical constraints prevent the formation of modern industrialised economies. In his assessment of Pacific Island economies, Higgins (1994, pp. 29-38) provides a comprehensive list of examples which amply demonstrate reasons why economies in the Pacific are unlike those operating in industrialised countries. Some of the reasons Higgins outlines are: distance from potential markets; insufficient natural resources; fragile eco-systems; small domestic markets; the reluctance of professionals to move into the region; and institutional and cultural resistance to change. The realities of "smallness" and "isolation" combine in the Pacific region to create an environment unsuited to

initiatives which rely on large volume of resource inputs, economies of scale and organisations with large groups of employees possessing specialised knowledge. "Resistance to change" suggests underlying concerns of local people over technology-based change.

Therefore, the strategies outlined by Enos (1991) and Bell and Pavitt (1993) are called into question for the practical reason that many of the basic elements required for sustainable development of modern technology do not exist in the Pacific region. Both Enos (1991) and Bell and Pavitt's (1993, p. 200) recognise this difficulty in their identification of the necessity for adequate economies of scale, but provide little direction to policy makers in places such as Pacific Island countries who are required to develop tangible responses to the realities of "smallness" and "isolation". While Enos acknowledges the problem of indivisibilities in small developing countries, his recommendations for large scale government coordination appears to be essentially at odds with the principal difficulties governments of developing countries experience - that is, the difficulties of gaining accurate information by which this coordination is made possible (Stiglitz, 1996, pp. 281-282).

In view of the findings of Chapter 2, which identified experiential knowledge development and communication as essential requirements for the development of technological knowledge in engineers, the problems of "smallness" and "isolation" represent a double edged sword. Engineers are likely to experience difficulties if their contact with other engineers is limited through small organisations. Contact with other local engineers involved in similar areas of technological activity may partially compensate for the problem of smallness. However, the distance which separate these engineers from overseas equipment suppliers, identified by Nelson (1978) as a singularly important source of technological knowledge, arguably represents another major impediment to learning.

Another concern identified by Higgins extends beyond the practical limitations of "smallness" and "isolation" to the issue of institutional and cultural "resistance to change" (Higgins, 1994, p. 37). Higgins is alluding to a similar concern expressed by Enos (1991, p. 175) where local communities do not readily accept the claim of superiority which is accorded to western knowledge forms and technology. In contrast to Enos however, Higgins suggests that the root of this discontent may be more intricately intertwined with local customs, beliefs and contingent circumstances and hence, more deep-seated than judged by Enos, who identified self-interest as the primary reason why local communities were averse to change. In coming to terms with barriers to the development of technological capability, the value of economic growth as a measure of capability development may not be wholly relevant if the social goal of economic efficiency is not central to the concerns of a particular community.

The need for further theoretical development is therefore most apparent on two accounts. Firstly, the wisdom of pursuing strategies designed to promote industrialisation in the Pacific region is questioned on the basis that the existence of "smallness" and "isolation" may mean that many technologies are not viable in the region. In terms of Pacific Island engineers, the most pressing issue from this perspective appears in the constraints which are imposed on communication amongst engineers and hence, the transfer of technological knowledge.

Secondly, the belief that social progress should be unequivocally factored on western modes of development is questioned on the basis that participants may not perceive this process of technological change as acceptable within the context of local values, hence leading to resistance to these changes. The implications this has for the development of engineers working within these communities is that they may not be automatically accorded the status and power to direct change that commentators such as Enos (1991) feel necessary. Where Enos (1991) portrayed engineers as being the cadre by which the

benefits of modernisation would be delivered, the following discussion of dependency theory reveals that engineers are implicated in undermining their own culture.

3.3 DEPENDENCY THEORY

Dependency theory represents a broad area of commentary in development studies which seeks to reveal the underlying political and economic dynamic of industrialisation. This approach purports to explain how developing countries are enveloped in a broader global hegemony which is not aimed at promoting the interests of poor countries (Fransman, 1986, pp. 59-60; Shrum et. al., 1995, p. 630). Dependency theorists therefore argue that economic and political ties bind developing countries into relationships which diminish their ability to autonomously direct policy. Hence, some have argued that the colonial power relationships of the past are reproduced in the dependant relationships of the post-colonial area, spawning the term "neo-colonialism" (Jary et. al., 1995, p. 439)

The dependency argument is extended by Shrum et. al. (1995, p. 631-632) into critiques of Institutional theory, particularly as it relates to isomorphism. As cited earlier, isomorphism describes the proclivity of organisations using modern technology in developing countries to emulate those in developed countries. Associations between rich and poor countries are not explicit but the reproduction of power relationships appropriate to interests in the industrialised countries has a similar net effect to that which dependency theory describes. The complicity of indigenous employees of such organisations is identified by the rewards they receive in terms of access to overseas education and the consequent higher status conferred on them by the organisation. As Shrum et. al. (1995, p. 632) state:

> [p]ractices, processes and national policies are adopted and transformed and reproduced not necessarily because of their technical superiority has been demonstrated but owing to participants' beliefs in the efficacy of certain ways of doing things. Science, like education, is one of the most significant institutions that provide interpretations, cultural meanings and instrumental leverages throughout the world.

The role of organisations is thus one in which they are outposts on the frontier of global capitalism. Interestingly, the belief held by Enos (1991, p. 113) that his advice for developing countries is not framed by any form of ideology (by virtue of the scientific nature he ascribes to technological knowledge) is seen by dependency theorists as being heavily biased by the political and economic aspirations embodied within western ideologies (Badham, 1984, pp. 67-68). Technological capability from the dependency theorists perspective is therefore a contentious term where individuals are educated and trained for the benefit of western political and economic interests.

Hill (1988; 1994) is one commentator who has devoted time to studying the inequalities induced by the transfer of western technology to the Pacific region. Central to Hill's (1988, pp. 52-55 & 74-89; 1994) critique on technology transfer to the Pacific region is his concern over the destabilising effects western technology has on local culture. Hill (1988, p. 41) ascribes western technology with an innate cultural power in which the technological artefact '...camouflages a rationale which has been formulated in many arenas far removed from the immediate task at hand...'. In view of the dominant role European culture has in technological developments, he argues these artefacts of technology reflect the imperatives of the industrialised world in both the knowledge required to effectively use these artefacts and the social and physical environments for which these artefacts are designed. If these requirements are at odds with the physical and cultural settings in which modern technologies are placed, it follows that the likelihood for serious social dislocation to local communities is great. This leads to the

pessimistic assessment that traditional cultures run the risk of being extinguished through technology transfer. Citing case studies from the Pacific, Hill (1988, pp. 85 - 86) states:

> [w]hen introduced into traditional societies, the transformative power of industrialised technologies is profound. A single technological artefact has the power to penetrate to the heart of traditional cultural stability and meanings. The power does not lie however in mere technical usefulness as a non-cultural analysis may suggest. Nor does it lie only in the abuse of economic hegemony, as a political-economic analysis might propose. Rather, the most basic source of transformative power lies in the cultural context from which technology is derived, a context that is implied at every point along the technology's path.

Molnar's (1994) analysis of Pacific broadcasting organisations yields a similar theme to that outlined by Hill. She perceives broadcasting technology as a vehicle through which the interests of foreign corporations and local politicians are promoted to the detriment of local culture. Molnar (1994, p. 106) states

> [P]acific broadcasters...[are]...vulnerable to overseas corporations selling their equipment, and to large overseas media groups who work directly with governments to set up media services. Consequently, the choice to adopt a form of communication technology can be based more on "political" interests than considerations of national media needs.

Molnar's main complaint is the lack of participation in processes which determine choices of broadcast technology. Along with Hill, she rejects the idea that technology is culturally neutral by arguing '...along with any communication technology comes a host of existing practices...which determine how the technology will be used...' (p. 105). Hence, she identifies advertising, playing western music, broadcasting overseas news bulletins and transmitting pre-packaged overseas programming as being the means by

which the interest of foreign corporations are promoted. The net effect is that Pacific Island broadcasting is best suited to the importation of foreign programme material, while the paucity of skills to undertake local programming reduces scrutiny of the political process. Molnar (1994, p. 117) writes:

> [t]he global dominance of western commercial media forms, and the subsequent importation of western commercial media into the Pacific appear to have obscured the potential of the media to be used for local production, and for cultural maintenance and regeneration.

Molnar (1994, p. 105) makes specific reference to Pacific-based broadcast engineers noting that they have difficulty maintaining equipment to an adequate standard. She states that they are dependant on information from foreign experts which constrains the ability of these engineers to make informed choices about equipment suitability (Molnar, 1994, p. 109). Contact with these western consultants is limited as most decisions are made in consultation with management and government further denying these engineers the opportunity to learn from these planning and design activities.

Both Molnar and Hill provide a sobering assessment of the deeper cultural implications of modernisation strategies for the Pacific. In contrast to the optimism which propels the introduction of new technologies into the Pacific region[1], Hill and Molnar present an alarming counter-view which reveals the destabilising effects of western technologies on local culture. Practitioners working for the organisations which use these technologies

[1] A good example of such optimism may be found in an advertisement in the June 1998 edition of the magazine, *Island Business* (p. 64) titled "How a small nation changed the course of world aviation history". The advertisement was placed there by the Civil Aviation Authority of Fiji who were announcing the implementation of a new '..Communication, Navigation, Surveillance and Air Traffic Management System (CNS/ATM)...' which had been trialed in Fiji for some time prior to the announcement . The trialing of satellite-based Global Positioning Systems (GPS) for air navigation was portrayed in terms of the epic struggle between David and Goliath, and just as David triumphed, Fiji's place in the development of air navigation history was assured into the next millennium by virtue of '...cutting edge...space age technology...'.

are portrayed as undermining the stability of local culture suggesting significant division and dislocation within Pacific societies.

3.3.1 Engineers: Pawns of a Global Hegemony?

If one reflects on the arguments of Noble (1997) detailed in chapter 2, who portrayed engineers as playing an integral role in supporting the capitalist hegemony, Pacific Island engineers working with modern technology can similarly be identified as being subject to the dictates of foreign interests. Molnar's (1994, p. 109) discussion reveals that broadcast engineers are trained in such a narrow range of skills, dependency on foreign experts and consultants is required to ensure the on-going operation of machines and equipment. Hill (1994, pp. 41-43) portrays the local practitioners who use western technologies, as leading a double life between traditional society and the technical world of their organisations.

The manifestation of the themes of "smallness" and "isolation" from this perspective are the unequal relationships of power which come from the limited contact Pacific organisations have with a few foreign organisations. In Molnar's analysis. these factors can be directly attributed to arrested levels of capability development. Notably, local culture, as portrayed by Hill and Molnar, appears as being relatively detached from the broader process of change factored on western technologies and its interaction with local politics. While suffering impacts, local culture appears from this perspective as being relatively impotent to influence the nature of these changes. "Resistance to change" appears as a somewhat muted response to disagreement over the direction and pace of change. Hill and Molnar's response to this problem is the development of technologies which are more appropriate to the physical and social environment of Pacific Island communities.

3.4 APPROPRIATE TECHNOLOGY

Hill (1994) and Molnar (1994) advocate the development of appropriate technologies and appropriate organisations which are designed with the constraints and needs of Pacific Island countries in mind. Central to this idea is transferring authority over the technology development and diffusion process to indigenous practitioners thereby giving them control over the pace and direction of change. For example, Hill (1994, p. 47) argues for technologies which balance economic development with cultural change maintaining that culture is an '...essential feature of design space...'. Molnar (1994, pp. 106-107) sees the development of small community based broadcasters as the most appropriate form of organisation to deliver much-needed local content to the programming of Pacific radio and television.

> "Small" media lend themselves more readily to indigenous use, and have the advantage of being able to provide local programme alternatives to the "big" national media (p. 106)

The use of small scale appropriate technologies is intended to allow adjustments to be made which ensure social cohesiveness within indigenous societies is maintained.

These recommendations by Hill and Molnar can be linked to the work of Schumacher (1973), author of the seminal text, *Small is Beautiful: a study of economics as if people mattered.* The background to Schumacher's work is found in his role as a development economist in Burma and India (Willoughby, 1990, pp. 55-97). Schumacher came to a realisation that western economics and technology were inconsistent with the immediate needs and demands of people, which were usually motivated by religious beliefs and culture. He surmised that the economic orthodoxy of western nations represented but one of many possible economic theories which could be developed. Hence, the appropriate

technology movement is characterised by its rejection of western technology as a universal panacea for developing countries and seeks to provide technologies which are designed to meet the specific needs of developing countries. One is able to gain some sense of the distance one has travelled in terms of theory by noting the reference to appropriate technology made by Enos (1991, p. 2). As he views the social environment as being the variable element in the process of technological change, he positions himself diametrically opposed to proponents of appropriate technology. While Enos perceives technology as the given element to which society must respond, appropriate technology theorists view society as being the given element to which technology design must respond.

Interest in appropriate technology within the Pacific region reflects many of the aspirations of Schumacher. Veramu (1998b, pp. 48-49) is a strong proponent of appropriate technology who argues that development initiatives should take account of the cultural and spiritual aspirations of the Pacific communities. In using the term, "the Pacific Way", Veramu (1998a, p. 51) questions the notion of a unitary approach to Pacific Island development maintaining that solutions and directions for change must emerge from local individuals and institutions who are most familiar with problems in their immediate environment. Development economist, Halapua, advances a similar theme in an economic model he has formulated to take account of social, cultural and spiritual values as well as the goal of economic growth (Petelo, 1997). In accord with Hill and Molnar, both Veramu and Halapua cite western influence over domestic policy formulation in the Pacific as the reason why decisions are made without the best interests of Pacific communities in mind. For example, Veramu (1998b, p. 49) complains that education is increasingly being used to equip Pacific Islanders to become '...productive units for their [World Bank] globalised economy...'. Halapua similarly complains about the changing role of regional bodies such as the South Pacific Forum (Field, 1998). While in the past ministers were able to bring issues of local concern to the attention of regional partners, the nature of this exchange has effectively been reversed - ministers are

now expected to take home and implement the measures foreign institutions perceive as being necessary. Federated States of Micronesia President, Jacob Nena, notes that such foreign institutions are the same ones who led many countries to develop five year plans underwritten by public investment which are now considered as misguided (Field, 1998).

While the principle of appropriateness in economic policy making and technology design are factored on the same concern over the dominance of western interests, both Veramu and Halapua are keen to not dissociate themselves completely from western knowledge. For example, Veramu (1998b, p. 48) sees an important role for western education as long as this role is one which co-exists with the '...empirical wisdom...' of local indigenous knowledge rather than displacing the later. Similarly, Halapua' views the goal of economic growth as an important element of his model on the proviso that this be subject to local values (Petelo, 1997). Notably absent from the arguments delivered by Veramu and Halapua is the sense of vulnerability of Pacific cultures characteristic of the general tenor of Hill's (1988, 1994) and Molnar's (1994) assessments. Veramu's and Halapu'a's "Pacific Way" suggests a confidence in Pacific culture which can "mix" and "match" both western and Pacific knowledge forms, including that which is embodied within modern technology.

One example of this is radio broadcasting which has been an important communication link to Pacific Island communities (Lie et. al. 1996, p. 17; UTS, 1997, pp. 16 & 19). Even the concerns expressed in Molnar's discussion are tempered by a recognition that radio broadcasting has been adopted to fill a need within the community.

> Radio's popularity is enhanced by programmes in indigenous languages and by the fact that it is very much an extension of the...network of interpersonal communication that exists in the islands (Molnar, 1994, p. 110).

In adopting a broader historical perspective, Samoan author and academic Wendt maintains that this process of adapting foreign cultural forms to suit local needs has been a feature of interactions with Europeans during colonial times. Hereniko (1997, p. 31) quotes Wendt as saying.

> [a]ll cultures in the Pacific have been changed by outside influences. But those have also been changed in the image of local culture. They have been indigenised and have led to more cultural change so that Pacific Island cultures are quite different to what they were pre-European. That doesn't mean cultures have died, it means in many ways, they have been strengthened.

While Wendt acknowledges that these periods of change have engendered considerable problems, (for example, along with Molnar, Wendt is also critical of local politicians), he sees the process of overcoming these issues as affirming and strengthening local culture - an essentially different argument to Hill and Molnar who portray Pacific cultures as being largely impotent in the face of centralised foreign and local power.

Wendt's views are supported by research into colonial interactions between European and Pacific Island countries. Thomas's (1991) anthropological examination of the exchange of artefacts between Europeans and Pacific Islanders between the seventeenth century and World War II represents one study which accords local cultural institutions with an active role in the formation of colonial relationships. Thomas (1991) argues that the properties of the exchanged artefact are not so fixed to a European understanding but are open to significant degrees of re-interpretation by recipients. Thomas (1991, p. 28) is fascinated by the '...mutability of things in re-contextualisation...' suggesting that the cultural frame of the recipients is an active influence in determining the power relationships of exchange and the uses to which these objects are put to. Hence, his critique is quite different to Hill (1988; 1994) who argues that the properties of technological artefacts are more or less prescribed by the developers of such technologies.

Similarly, Hempenstall's (1978) study of German colonialism in the Pacific region yields an interpretation which ascribes Pacific culture with a considerable degree of power and influence over colonial relationships. Hempenstall (1978, p. 222) surmises, that while the relationship between Germany and its colonies undoubtedly favoured the former, this should not be allowed to disguise the '...creative side...' of indigenous politics which were essentially struggling for the survival of their culture. He cites examples where Pacific Islanders, through their leaders and institutions, often took the initiative which at times left their European "rulers" bereft of alternatives to further their colonial objectives (pp. 201-212). Often these initiatives had more to do with securing local political ends rather than actively opposing or supporting the colonial administration. Hempenstall (1978, p. 222) states '...[Pacific] societies were dynamic enough to adjust of their own accord and to a level upon which they themselves had decided...'.

Thomas's summation appears to have some merit in an analysis of technology transfer today. Thomas (1991, p. 35) writes:

> It is often supposed, in both conservative and radical thinking, that imperial intrusions have had such a shattering effect upon the dominated groups that the form of local, pre-colonial society is of limited significance for subsequent development; even when struggle and resistance are recognised, the responses of the colonised are taken to be merely reactive. While the real balance of forces at particular phases of colonial history requires specification, and there clearly are times when indigenous peoples cannot do much to shape events which overtake them, I am committed to the view that local relations and representations are never totally encompassed or determined by the violence of colonialism, and that the distinctive forms of indigenous sociality and politics contributes in a crucial way to the dynamics of accommodation and resistance constitutive of colonial history.

Thomas (1991, p. 186) goes on to conclude:

> It would seem important then to avoid establishing any theoretical principle about the relative significance of external dominance or global relations as against local autonomy and appropriation.

By assigning local culture with an instrumental role in the process of technology diffusion and adaptation, one could speculate from Thomas's and Hempenstall's studies that the organisation which emerges in these circumstances is one which is motivated primarily by the need to serve local interests. In this light, the use of the term "resistance to change" appears too passive as its does not capture the possibility that the process of change is far more open to direction from institutions in local culture than given credence in both modernisation and dependency critiques.

3.4.1 Engineers: Part of the Pacific Way?

In terms of identifying a social function for engineers, the literature on appropriate technology is most explicit. Willoughby (1990, pp. 207-209) equates the concepts of appropriate technology and "good engineering" on the basis that no engineer should wish to see any application they have designed fail when set to work within the community. However, distinguishing a role in Willoughby's commentary for the local Pacific Island engineers is more difficult. One could argue that the message which emerges from the literature on appropriate technology towards such practitioners is quite negative - special allowances must be given to account for an "inability" to cope with the demands of modern technology. Accusations of paternalism made by some in developing countries appears to reflect a concern that the potential and actual capabilities of indigenous practitioners are being underestimated by appropriate technology proponents (Willoughby, 1990, pp. 236-238). On the other hand, it is less clear as to what social

role observers such as Veramu (1998a; 1998b) and Halapua (Field, 1998; Petelo, 1997) perceive for engineers.

In asserting a more instrumental role for Pacific Island cultures in the process of technology diffusion, the nature of the modern Pacific institution which uses western technology may be more orientated to serving local, rather than, foreign, interests. The role of those employed in these organisations, such as engineers, is thus seen as one in which they are similarly subject to the authority of local interests. The implications for understanding the ways in which western technologies are adopted, or re-contextualised, is that the process is one which is largely unscripted. In much the same way Bell and Pavitt describe the need for innovative activity in adapting new technologies to foreign settings, the analysis suggests a broader vision of technology diffusion as a community wide project in which engineers play a critically important role.

3.5 CONCLUSION

The discussion in this chapter has established the need for technological capability development theory which is able to account for the specific circumstances in the Pacific region. With reference to the three themes of "smallness", "isolation" and "resistance to change", two significant findings are drawn from the discussion.

Firstly, the existence of "smallness" and "isolation" indicate the absence of conditions necessary for industrialisation, the central proposition driving the studies of technological capability by Enos (1991) and Bell and Pavitt (1993). More particularly, "smallness and "isolation" have implications for the establishment of productive knowledge sharing relationships among engineers. Acknowledging that there is limited scope for communication when organisations are small and contacts with external sources of knowledge are limited by distance, the need to become better acquainted with factors

which govern the transfer of knowledge into Pacific Island organisations becomes most apparent.

Secondly, the issue of "resistance to change" alludes to the broader social process within Pacific Island communities and its relationship to the introduction of foreign technologies. As the organisation is identified in Chapter 2 as playing an instrumental role in technological capability development, the ensuing question is what affect do these broader social processes have on the Pacific Island organisation and the development of technological capability in its engineers? An analysis of the literature reveals considerable disagreement over the processes which explain technology diffusion in the Pacific region. The three alternative portrayals of the "quintessential" engineer drawn from the literature provide a basic framework to deal with this uncertainty. They are intended for the latter analysis of research data to enable examination of relationships between social process and the development of technological capability.

In summary, there is a need to tailor technological capability development theory in response to the constraints of "smallness", "isolation" and "resistance to change". The analysis within this chapter suggests the need for a keener focus on the institutional links aspect of Bell and Pavitt's (1993) study, particularly the factors which govern the establishment of links for communication between engineers inside and outside the organisation. Additionally, the discussion in this chapter provides reason to be cautious about accepting the goal of economic efficiency as an appropriate measure of technological capability development, as suggested by the two studies of technological capability. It is far from clear whether Pacific Island communities are desirous of a future factored on western goals and values.

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Chapter 4

The Information Perspective

4.1 INTRODUCTION

The purpose of this chapter is to draw together the discussions of the previous two chapters and to determine an appropriate method by which to proceed in this analysis of technological capability development in Pacific Island engineers. To that end, initial attention is devoted to formulating a statement describing the research problem. Five questions are drawn up to illuminate different aspects of this research problem. In response to these questions, an interpretative research methodology using case study investigation is explained as being most appropriate to the research problem. The work of Macdonald (1992; 1995; 1998a; 1988b) is proposed as an analytical tool by which to interpret the case study data. Macdonald focuses on the specific roles of information during problem solving which is described by the term, "information perspective". The suitability of Macdonald's information perspective is argued on the basis that it responds to the three main areas of uncertainty associated with the research problem:

the role of problem solving in knowledge development;

the significance of information external to the organisation; and

the role of the organisation in facilitating or constraining problem solving.

As Macdonald's framework makes no *a priori* assessment about the nature of the organisation, except for its ability to facilitate access to problem solving information, this information-based rationale is able to accommodate the uncertainty associated with defining the purpose and nature of the Pacific Island organisation's role.

4.2 STATEMENT OF THE PROBLEM.

The discussions in the previous two chapters endeavoured to assess the degree to which two significant studies on technological capability (Enos, 1991; Bell and Pavitt, 1993) were able to respond to the special conditions of engineers working in the Pacific region. Chapter 2 investigated the extent to which these two studies accounted for the development of technological knowledge by investigating empirical studies of engineers. Chapter 3 assessed these two studies in the broader context of development literature pertaining to the Pacific region from which the three themes of "smallness", "isolation" and "resistance to change" were identified as impediments to the development of technological capability in engineers. In bringing the discussions of chapter 2 and chapter 3 together, three points are formulated to summarise the most important issues relevant to technological capability development of Pacific-based engineers.

Firstly, tacit knowledge development through experience and communication between engineers is recognised as an important component of technological capability development. There is sufficient reason to distinguish this form of learning from the learning which occurs in more formal settings, such as educational institutions and training courses.

Secondly, the reality of small organisational size and isolation from more experienced practitioners is viewed as being detrimental to the development of technological capability in engineers.

Thirdly, the identification of "resistance to change" by Higgins (1994) is used here to indicate that there is considerable disagreement over the purpose and nature of Pacific-based organisations and their engineers in the literature surveyed. Therefore, use of the term "resistance" is tentative because there have also been instances to suggest that there has been little resistance to technology diffusion - radio broadcasting being one example identified from the literature.

In view of the importance of experiential knowledge development through problem solving and communication, the research problem appears to be to define the degree to which the Pacific themes of "smallness", "isolation" and "resistance to change" intercede on these knowledge creation processes of engineers within the organisation.

Question 1. The principal research question the thesis seeks to address is:

how do engineers solve problems within the Pacific contexts of "smallness", "isolation" and "resistance to change"?

Four further questions have been formulated to illuminate different aspects of this principal research question.

Question 2. The first of these questions is drawn from the analysis of chapter 2 and seeks to determine the significance of problem solving to the engineers.

What factors can be identified as contributing to the experience of problem solving for Pacific Island engineers?

Question 3. Drawn from the concluding analysis of chapter 2 and explored in greater depth in chapter 3, this question seeks to determine the extent to which the organisation is implicated in facilitating or constraining the problem solving of its engineers.

In what ways does the organisation facilitate or constrain problem solving?

Question 4. If the organisation is implicated in problem solving, it seems important that some understanding of the factors which shape the organisation be developed. This question is directed at determining from the research data which of the three scenarios of the organisation and its engineers portrayed in chapter 3 is most appropriate ("Cadres of Modernisation", "Pawns of a Global Hegemony" or "Part of the Pacific Way").

Which scenario presented in chapter 3, is most appropriate in understanding the organisation and engineers under scrutiny in this study?

Question 5. The last question is designed to draw conclusions about the relationships that exist between the broader social milieu and the Pacific Island engineer in relation to the development of their technological capability.

What implications does this finding have for an understanding of technological capability development for Pacific Island engineers?

4.3 METHODOLOGY

The following discussion proposes that an interpretative research methodology is the most appropriate response to the problem described in the previous section. In determining where such a methodology is placed within the general scheme of social research, Metcalfe (1996, pp. 24-29) uses the quantitative-qualitative dichotomy as a guide and assigns interpretative research to the latter group. Metcalfe differentiates between these two broad methodological approaches on the basis of whether the research question is best understood through measurement or through descriptions which reflect the '...lived experience...' (p. 28) of subjects. Alvesson (1995, p. 42) elaborates on this idea.

> Interpretation is the act of giving a phenomenon meaning or discovering...something of...its inherent meaning or significance. Interpretation describes underlying context or meaning, the not so obvious content of a word, sentence action or event.[1]

In endeavouring to gain an understanding of the factors which influence the actions of people some argue that it is mandatory that context be explicitly acknowledged as a source of such influence. For example, Callon (1992, p. 74) maintains that the

> the behaviour of actors is intelligible only within the context in which they are being considered...No actor can be disassociated from the relationships that actors enter into.

Lincoln and Guba (1985, p. 25) argue that ignorance of context represents a major deficiency of positivist social research methodologies based on the scientific method.

[1] Alvesson (1995, p. 41) cautions that there are some who use the description of qualitative research but are still orientated to quantifying relationships through measurement. In this sense, the tag of "qualitative research" appears to refer more generally to social research of which there are, as Alvesson (1995, p. 41) describes, the '...data collectors...' and the '...interpreters...'.

> Positivism thoroughly confuses two aspects of inquiry that have often been called the "context of discovery" and the "context of justification". The former deals with the genesis or origin of scientific theories and the latter with testing them. Positivism excludes the former and focuses on the latter.

Yin's (1994) work on detailing the purpose and design of case study research formalises many aspects of conducting investigations in '...real-life contexts...' (p. 1). Case study research, from Yin's (1994, p. 1) perspective, is for those who have posed exploratory "how" or explanatory "why" research questions. Case study research is accordingly most appropriate if the questions concern contemporary events over which the researcher has little control or in circumstances in which it is difficult to distinguish between context and the phenomena under scrutiny.

Yin (1994, p. 20) also details the need to ensure that there is a logical link between the research question, the units of analysis, the data to be collected and the criteria for interpreting the data. Metcalfe's (1996, p. 40) discussion on the purpose of argument in interpretative research agrees, but rather for the more basic reason that logical associations are the essence of good argumentation. However, there is an obvious contrast between the structure Yin seeks to impose in the design stage of case studies in order to ensure that validity and objectivity are constructed within the study and the arguments advanced by Alvesson (1995) and Metcalfe (1996), who question whether such validity and objectivity is obtainable. Both Alvesson and Metcalfe refer to the work of Kuhn (1970) in revealing the influence contingent social circumstances may have over the pursuit of objectivity and the degree to which established theoretical principles shape the course of research by privileging certain kinds of data over others. Metcalfe (1996, pp. 1-13) maintains that no scheme or method can unequivocally prevent the effects of personal bias or dishonesty. Rather, Metcalfe (1996, pp. 39-66) and Alvesson (1995, pp. 42-44) argue that it is better that the researcher acknowledge bias in their deliberations over theoretical concepts and

translate this into constructing well-founded and interesting arguments. Alvesson (1995, p. 49) explains that:

> qualified empirical research is primarily a case of being aware of theory and metatheory, continuously reflecting on the current position and future developments when reading and conducting empirical work, and being open to ideas and suggestions - often generated by a combination of literary inspiration, thought and what is read.

Hence, the process of developing an understanding through interpretative research is aimed at theory building and is one of reasoned argument supported by evidence elicited from a diverse range of sources (Metcalfe, 1996, p. 48). The attainment of objectivity is through the scrutiny and approbation of a knowledgeable audience (Metcalfe, 1996, pp. 14-16).

To some extent, the work of establishing the logical associations referred to by Yin (1994), Alvesson (1995) and Metcalfe (1996) has already begun: the literature review, from which the research questions were derived, has already identified the primary units of analysis as engineers, the organisation in which they work and the machines and equipment they manage. The nature of the data to be obtained and the interpretative framework to be employed in understanding this data still require attention. The need for an interpretative framework to analyse the data is important in ensuring that data collection is oriented to best illuminating the research question from which new theoretical insights may be developed. Alvesson (1995, pp. 44-49) describes this in terms of a metaphor where understanding is achieved by comparing data with a familiar concept. It is in this context that the next section explores a rationale advanced by Macdonald (1992, 1995, 1998a, 1998b) as a means of providing an interpretative framework through which the empirical data will be analysed.

4.4 AN INFORMATION PERSPECTIVE ON PROBLEM SOLVING IN THE ORGANISATION

The value of Macdonald's (1992; 1995; 1998a; 1998b) insights into the role of information in problem solving is in the direct relationships which can be established between its key concepts and the major issues of concern reflected in the research questions. More specifically, Macdonald's information perspective is characterised by its emphasis on three issues: problem solving as a learning process; the importance of external information in solving intractable problems; and the critical role the organisation plays in acquiring problem solving information. As reflected in Table 4.1, these three concepts can be related to the three areas of contention from which the research questions were derived.

Critical Issues from Literature Review	The Response of an Information Perspective
Experiential knowledge development	Coping with change through problem solving constitutes learning.
The need for communication with experienced "others" outside the organisation	The importance of external information in the solution of intractable problems.
Undetermined nature of the goals driving the Pacific-based organisation	The undefined nature of change allows the organisation to be judged on its ability to acquire information to resolve "locally-defined" problems .

The Suitability of the Information Perspective

Table 4.1

4.4.1 Background to the Information Perspective

Macdonald's work is part of a broader area of information-related research distinguished by its desire to identify attributes of information that are of economic and social significance (Lamberton, 1997, pp. 1-2). The goal is to give what is essentially an intangible resource due recognition within theory used to dealing with tangible resources (Mandeville, 1996, p. 1). Discerning the contrasts between codified and tacit knowledge is hence actively pursued where the complementarities between codified information (machines, equipment, processes, documents, etc) and uncodified information (skill, know-how, etc) represent the key to understanding the underlying processes contributing to an organisation's and economy's performance (Lamberton, 1997, p. 6). Mandeville (1996, p. 91) portrays technological advance as essentially a process in which only a portion of the total information required to enable the development of an innovation is codified - the transfer of the remaining portion dependent on information flow between actors being essentially a '...collective, social and informational process...'.

Macdonald draws his insights from a variety of historical and geographic contexts beginning with seventeenth century agriculture in Britain to the technologically dynamic firms of Silicon Valley in the United States. By putting information first in his analysis, Macdonald (1998a, pp. 1-12) reveals a number of peculiar characteristics which have not been explicitly recognised in the voluminous writings on information and information technology. Macdonald's perspectives on information are underpinned by the notion that information has unusual economic characteristics and the skills individuals and organisations develop in coping with these characteristics have implications for the ways in which they learn. In short, Macdonald (1998a, pp. 12-27) argues that difficulties in establishing common perceptions about the value of information between the seeker and supplier led him to identify the "information transaction" as a necessary element in the

transfer of problem solving information. Information networks emerge from his analysis as a means to facilitate both the transaction and the transfer.

The value of Macdonald's analysis to this thesis lies in the three foci of his information perspective: problem solving, external information and the organisation's role in facilitating access to problem solving information (see Table 4.1). These three issues are reflected in Macdonald's (1995, p. 558) summary of the information perspective.

> [I]ts methodology is essentially and deliberately analogous to its hypothesis: that the essence of change in the organisation is the external information required for learning, and that understanding of the process of change lies in appreciation of not simply how this external information may be used within the organisation, but of how this information may be found and acquired beyond the confines of the organisation.

Change is defined by Macdonald (1998a, p. 37) as '...the transition from one state to another...'. The unspecified nature of change in the above definition is quite deliberate as change may emanate from many sources within and external to an organisation (Macdonald, 1995, p. 558). Macdonald's rationale is that implicit to change, whether it is planned or forced upon an organisation, is uncertainty. As the means by which uncertainty is overcome is, by definition, never fore-known, existing information within an organisation must be employed in new ways or new information from outside the organisation may need to be acquired (Macdonald, 1995, p. 560). The separate activities of finding this information, acquiring it, and then using it, from Macdonald's standpoint, constitute the learning which occurs through problem solving.

In contrast to other information-based approaches which seek to define the hierarchical associations which distinguish information from knowledge and data,[2] the emphasis here

[2] For example see Menou (1994, p. 7) and Thorngate (1995) for a discussion about these approaches.

is on the individual and empirically derived attributes of information when used by the individual. As Macdonald (1995, p. 558) asserts, it is the individual who learns and though this may be done collectively with others within the context of organisations, the factors which assist or impede their development logically need to be referenced to the individual faced with the problematic situation. Stiglitz (1996, p. 281) also places the individual "centre-stage" by asserting that individuals, in their use of information, are rational in that they '...act in a (reasonably) consistent manner, one which adapts to changes in circumstances...'. As Stiglitz was referring to individuals in developing countries, the underlining principle appears to be one which asserts the commonality of human experience when faced with the uncertainty of learning or discovering new ideas. Similarly, the application of temporal distinctions to information, such as the first time discovery of an idea, is of little consequence when adopting the frame of reference of the individual. As Rogers and Shoemaker (1971, p. 19) state, '...[i]f the idea seems new to an individual, it is an innovation...'.

The concept of external information is important to Macdonald's rationale as it denotes the information which may be required during problem solving. The alternative, Macdonald et. al. (1992, p. 79) argue, is creating or discovering this information for oneself, which is akin to the slow and arduous task of '...re-inventing the wheel..'. This aspect of Macdonald's analysis marries well with Bell and Pavitt's (1993, p. 170) comments about learning-by-doing which argue that learning-by-doing only partially explains the learning of technological knowledge. Macdonald accords specific significance to information lying outside the organisation on the basis that the organisation is probably most proficient at using its own information resources. The presence of an intractable problem implies that these information sources are not sufficient in meeting this demand, signifying the importance of information which is external to the organisation.

When analysing the particular constraints of "smallness" and "isolation", the pertinence of external information is apparent. As outlined in chapter 3, smallness implies insufficient

numbers of experienced practitioners in the Pacific region by which to gain the necessary economies of scale for problem solving and, by implication, knowledge creation. This distinguishes external information as an important resource to Pacific Island engineers. Add to this the other theme of isolation and it becomes clear that the dynamics governing the transfer of external information over large the distances of the Pacific is an issue of importance. The information perspective responds to this constraint by outlining a role for both individuals and organisations in acquiring information which is external to the organisation. The following descriptions of Macdonald's information perspective delve deeper into the informational ability of both the individual and the organisation within the context of the importance information external to the organisations holds for problem solving.

4.4.2 Informational Capability and the Individual

The Problem of Needing to Know What One Does Not Know.

The dichotomous portrayal of technological knowledge, based on its codified and tacit attributes, was described in Chapter 2 as problematic because empirical studies of engineers revealed these alternative forms of knowledge interceded in problem solving in an "ad hoc" way. Macdonald provides an explanation which integrates both codified knowledge and tacit knowledge development in a single informational process. Macdonald uses this explanation to define an individual's competency as an ability to use and demand information.

As the individual is the central actor in problem solving, the capabilities of this individual are argued to be of primary significance. Macdonald (1998a, pp. 13-15) maintains that this ability falls between two theoretical extremes - one of total ignorance and the other of full knowledge. Ironically, neither of these two states represent a need for information. While the person with full knowledge has no need for information, complete naivety also

has no requirement for information as one is unable to even begin to express what they would wish to know. Hence, Macdonald maintains that an ability to demand information is based on one's knowledge of what they do not know.

The competencies of individuals is therefore interpreted here as having an understanding of one's own ignorance and represents a critical factor determining an individual's ability to discriminate what "kind" of information they require. The dilemma for the person faced with a problematic situation is that they are constrained in seeking help because they do not know what they need to know. If one reflects on the studies of technological development cited in Chapter 2, the significance of this difficulty can be discerned in Staudenmaier's (1985, p. 106) discussion when he states that the impetus for new knowledge is being able to interpret the significance of problematic data by being able to formulate a question. Similarly in Orr's (1996, pp. 125-127) study of photocopier technicians, the means by which competence was demonstrated through story telling was partly a reflection of knowing *which* of these stories to draw upon during problem solving. The stories can be seen as being important in defining areas of ignorance.

The "Puzzle-like" Nature of Information.

Macdonald goes on to argue that the difficulty of demanding information is best understood if one views information as having a puzzle-like nature. Macdonald (1995, pp. 559-560; 1998a, p. 50) sees information as representing individual '...bits...' to a puzzle, the puzzle being technology which is made up of an integrated assemblage of information embodied in machines, people, documentary sources and processes (see also Macdonald, 1983). In problem solving, the solution is the missing pieces to the puzzle of which the size and shape may be highly specific and under-determined. The uncertainty of problem solving emanates both from not knowing what the size and shape of the required information is, and from not knowing where these "pieces" may be found. Problem solving may also require a rearrangement of these pieces in order to get a better

fit. Ideally, each piece of additional information further enhances the definition of the problem (that is, the remaining pieces to be filled). Importantly, Macdonald (1998a, p. 43) notes that theoretical information may not warrant special status in view of the importance the last missing piece has in completing the puzzle, that is, solving the problem.

The notion of information as individuated pieces of a puzzle contributes to a better understanding of an individual's ability to use information. For example, some previous understanding or past experience of how the puzzle is meant to fit together is useful knowledge in attempting to reassemble such pieces or discover a missing piece during problem solving. Orr (1996, p. 122) alludes to this when he also uses a puzzle metaphor to describe the problem solving endeavours of his subjects.

> [T]he technician has a closed set of information resources that do not necessarily provide definitive answers. The bits of the puzzle must be examined in the light of experience to see which combination provides the most reasonable representation of the problematic situation.

Education, training and personal experience, together, appear from this perspective as the means by which people develop a readiness not only to receive and use information but also to demand further information. In contrast to ideas of education based on the adequacy of theory to provide the answers in advance of the questions which may arise in the field, learning from an information perspective is portrayed as an iterative process where one's engagement with the problem and other sources of information contributes to an incremental increase in ability to better define one's gaps in knowledge by which demands for further information can become more refined. Macdonald's (1998a) conceptual framework provides the means of integrating formal education, experiential learning and interpersonal communication within one informational process. The

capability of the individual is viewed from an information perspective as the ability to better define one's areas of ignorance.

As well as experiencing difficulty in defining what the "size" and "shape" of the missing piece of information is, Macdonald (1995, pp. 560-561) identifies another obstacle to knowledge development through problem solving - the problem of knowing *where* to find this information. In effect the information seeker is caught in a double bind because they are partially ignorant of what information they require and are also faced with the prospect of having to find this ill-defined piece of information from the stocks of information which lie inside the organisation. If the problem is intractable, the information seeker is then faced with the task of finding this information from the vast stores of information which are outside the organisation. The next section explains that information networks are an effective means by which these information-related difficulties can be reduced.

4.4.3 Informational Capability and the Organisation

As information must be acquired from somewhere, the difficulties of expressing demand relate to just half of the information transfer process. Understanding the other important aspect of information transfer, arranging supply of this information, brings to light the fundamentally important role the organisation plays in acquiring such information. The difficulty Macdonald identifies with the acquisition of information is derived from the assertion that information has value to both the person who requires this information and the person who possesses the information. Behind this argument is a debate over the economic characteristics of information and its uncertain status as a public or private good. This debate is briefly outlined here within the context of Antonelli's (1997) discussion on the subject.

The Value of Information and the Necessity for Information Transactions.

The study of knowledge sharing relationships between individuals within and between organisations is the basis on which Antonelli (1997) describes two dominant modes of information transfer, which he associates respectively with a public and a private goods character of information. Antonelli (1997, p. 72) equates the commonly accepted model of knowledge transfer described by Arrow in the early 1960s as one in which information is considered a public good. This is based on the reasoning that the information from research and development is expensive to produce but easy to copy and transfer. The analogy of information transfer he describes using this public goods understanding of information is accordingly a '...top down process of deduction from known scientific principles...' (p. 72-74 & 75). In contrast to this, Antonelli (1997) observes that technological knowledge development is also informed by the localised learning-by-doing of experience as well as communication with other workers, customers and suppliers. Antonelli characterises this mode of learning as a '...bottom-up systematic process of induction from actual experience and communication...' (pp. 74-75). Under this latter scenario, Antonelli (1997, pp. 75-76) argues that information derived from experience has characteristics of a private good in that the knowledge gained from experience can be appropriated for one's own benefit. In addition to this, the interrelated nature of information (such as explained using the puzzle metaphor earlier) suggests that the ability to use a piece of information is dependent on the possession of other complementary pieces of information. Under the second analogy, it is apparent that information derived from tacit knowledge has what both Antonelli (1997, p. 75) and Lamberton (1997, p. 7) describe as a '...quasi-private goods character...'. If that is the case, information can be appropriated for one's exclusive use and inducement may be needed to persuade the possessor of this information to part with it.

It is with this understanding of the private goods character of information that Macdonald (1995, pp. 560-561; 1998a, p. 13-17) builds his understanding of the dynamics which

govern information transfer. He develops this central theme by comparing the need to conduct transactions for the supply of information with the more familiar market exchange of tangible goods. From the perspective of both the information seeker (the "buyer"), and the information supplier (the "seller"), a number of problems arise when information is being transacted. The problem for the "seller" of information is that the "buyer" cannot be fully informed about the information without giving it away in the process. In view of the costs of generating information, this situation is made more uncertain by the prospect that this information may be transferred to other agents. Therefore, once information is supplied, the prospect of future benefit is reduced as exclusivity of ownership is compromised.

On the other hand, the "buyer" of information cannot express demand for something he or she does not know. In view of the vast amounts of available information, the life of the buyer is made more complex in actually finding where this information may be. A factor which may effect both the "buyer" and "seller" is the speed by which information can lose currency and relevance and by implication, value. Hence, establishing a common value between "buyer" and "seller" is fraught with many complexities and leads Macdonald to identify the information transaction as complicating the apparently simple process of information transfer.

The Importance Of Information Networks in Facilitating the Information Transaction.

Macdonald argues that information networks are a natural response to these unusual economic characteristic of information (Macdonald, 1998a, pp. 23-27). Broadly stated, information networks ensure that information of some '...mutuality...' is available to members of the network thereby reducing the difficulties of the "buyer" in expressing demand (Macdonald, 1992, p. 56). Information networks also work to ensure that compensation is made to the supplier of information.

In explaining the significance of information networks, Macdonald (1992, pp. 54-59; 1995, pp. 565-565; 1998a, pp. 23-27) draws a distinction between "formal" and "informal" information networks. Formal information networks are regarded as those sanctioned by the organisation and designed to ensure information is distributed to designated people on a "need-to-know" basis. Therefore, information networks within the organisation reflect the authority which is conferred to individuals in order to promote efficiency. As Macdonald (1998b, pp. 299-301) explains, the efficiency achieved through establishing set lines of command and information flow is a trade off against a reduction of flexibility. Those supplying information to the organisation by way of previous education or experience are compensated through wages and salary (though it appears that enthusiasm for work, coercion or fear may also be factors affecting one's desire to supply information).

Macdonald (1995, pp. 563-564; 1998a, pp. 24-25) contends that people also participate in informal information networks which are based upon personal relationships, common interest and trust (see also Dickson, 1996, pp. 129-139; Macguire et. al., 1976, p. 60). Informal networks are portrayed as being most suited to the characteristics of information because expressions of demand can be more specific as individuals have a better understanding of what other members find important. Informal information networks are therefore, identified as being most suited to the transfer of tacit or "difficult-to-get" information (Macdonald, 1998a, p. 22).

Compensation for the information supplier in informal networks is unlike that which occurs within information transactions over formal networks. The emphasis on trust and friendships in informal information networks gives the supplier some confidence that compensation will come by drawing on others in the network at some future time - that is, by payment in kind. Participation in informal networks is thus one of giving as well as receiving. Interestingly, Macdonald argues that those with a record of not contributing are naturally excluded from the network over time (Macdonald, 1992, p. 55).

Macdonald (1998a, pp. 21-23) uses the example of conversation to argue that informal information transfer is most suited to the characteristics of information. For example, conversation entails the exchange of information where calculation of the value of this information is manifest in the range of responses in the listener, such as deep interest or boredom. Individuals tend to seek out those who interest them most on the basis of knowing the other's area of expertise. Listeners who are able to assess the value of such information are likely to be able to respond with more information of a similar kind. Conversely, conversation is difficult when listeners are unable to judge the value of such information and respond with incongruous information. Conversation also provides an effective means by which verification and amplification can be sought.

Macdonald's discussion has obvious similarities with Orr's (1996, pp. 144-148) study which provides a pertinent example of the necessity and efficacy of informal information transfer. The knowledge of other experienced technicians is an important source from which information may be derived and is transferred primarily through conversation. The reward that the technicians of Orr's study receive for sharing such information is enhanced status within the group. The technicians also know that the group stands ready to assist if one of them experiences difficulty in resolving a machine fault. Orr identifies the contacts some technicians have with members of another division responsible for the design of these photocopiers as enhancing the status of these individuals within the group. Notably, the nature of these contacts are informal as they are not officially sanctioned by the organisation, but are dependent on personal relationships.

The significance of formal and informal information networks to Macdonald is that both are important to problem solving. Macdonald (1995, p. 561) argues that organisations are naturally best suited to dealing with familiar and formal information sources. The status of informal information networks within the organisation reflects the extent to which organisations are able to recognise and respond to the unusual characteristics of

information. Macdonald (1998a, pp. 27-33) maintains that many organisations treat information as a conventional economic commodity and as a consequence, are either ignorant of the benefits informal networks may provide to the organisation or even have worked against the formation of such networks lest they undermine established lines of command. In contrast, Macdonald (1998a, pp. 166-168) cites the example of organisations, such as dynamic leading edge companies in Silicon Valley, that actively encourage informal information transfer as a means of obtaining new information from other firms. These companies realise that their own information may also be at risk through these informal alliances, but accept this in the confidence that they will gain much more by being recipients of such information.

Therefore, organisations are identified by Macdonald as playing an instrumental role in procuring information. While obvious examples relate to formal transactions of information, such as the provision of education and training to employees, the attention the organisation gives to acquiring information relating to "difficult-to-get" tacit information from unfamiliar sources is indicative of an organisation's ability to respond to difficult problems. Organisations play an instrumental role in obtaining information which lies outside its boundaries. Set within the context of the need for individuals to have access to such information in their efforts to build up their own informational ability, the organisation's informational ability is found to be a fundamentally important element in this process.

4.4.5 New Perspectives on the Development of Technological Capability

Macdonald's insights into information suggest a new understanding of technological capability development in a number of ways.

In terms of the dichotomy between codified and tacit knowledge exhibited in Bell and Pavitt's (1993) study and argued to be problematic by Lamberton (1998, p. 188), Macdonald's focus on change, problem solving and the information needs of the problem solver provides a means by which the codified and tacit aspects of technological knowledge can be viewed as part of one process based on information.

In identifying the organisation as an important site in which learning occurs, Bell and Pavitt (1993) argue that organisations should invest in the development of tacit knowledge. Macdonald's response is to distinguish this responsibility of the organisation in facilitating the acquisition of problem solving information to its employees.

Bell and Pavitt observe that the existence of intra- and inter-organisational links are a feature of technological capable organisations. Macdonald is able to articulate why such networks are crucial for knowledge development on the basis of the unusual economic characteristics he ascribes to information and the information transaction. Information networks are viewed as the means by which the information transaction is facilitated - the reduction in search costs for the information seeker and the confidence information networks provide to the supplier of information that some benefit will be forthcoming.

The dominant issue arising from the literature review in Chapters 2 and 3 is the significance to the Pacific Island engineer of communication with experienced practitioners in overseas organisations. The acquisition of information which is external to the organisation is seen from Macdonald's information perspective as central to an organisation's problem solving ability.

Finally, the unspecified nature of the problem in Macdonald's discussion is argued to be useful in this analysis because there is doubt over what factors are driving the adoption of foreign technology in the Pacific region. The analysis in Chapter 3 questioned whether the goal of economic growth, the basis of Enos's (1991) and Bell and Pavitt's (1993)

study, accurately reflects the aspirations of Pacific Island countries. It therefore seems prudent to adopt an interpretative framework which is not dependent on preconceived notions of the social purpose to which organisations and capability development strategies are directed.

In summary, the issues of problem solving, external information and the informational ability of both the organisation and the individual are incorporated in this analysis through the scrutiny of the information transaction. By analysing the various aspects of the information transaction, the goal is to determine barriers to the acquisition of problem solving information outside the organisation. The attitudes of the organisation to external information is proposed as an important factor determining the ability of these engineers to solve problems.

4.5 CONCLUSION

A survey of literature on both the creation of technological knowledge and Pacific Island development identified areas in which the received theory on technological capability development required further attention in order to account for the specific conditions in the Pacific region. The Pacific themes of "smallness", "isolation" and "resistance to change" ostensibly represent serious impediments to the development of technological knowledge in Pacific-based engineers. The research questions are designed to determine the ways in which the physical and social environment, including the machines and equipment of technology, intercede in the problem solving endeavours of the case study subjects.

Macdonald's insights into the role of information in problem solving are intended as an analytical tool by which to interpret the case study accounts. Underlying Macdonald's

"information perspective", is the idea that information has unusual economic characteristics and the skills that individuals and organisations develop in coping with these characteristics have implications for the ways in which they learn. In short, Macdonald argues that difficulties in establishing common perceptions about the value of information between the seeker and supplier lead him to identify the "information transaction" as a necessary element in the transfer of problem solving information. Information networks emerge from his analysis as a means to facilitate both the transaction and the transfer. Central to this research, therefore, is interest in and scrutiny of the information transaction.

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Chapter 5

The Social And Technical Dimensions Of Problem Solving

5.1 INTRODUCTION

The next three chapters aim to come to a meaningful understanding of the experience of problem solving of engineers working in an organisation in the Pacific region. The arguments laid out in the previous chapters culminate in the basic claim that problem solving within the organisation is of critical importance to the capability development of engineers. However, the literature review suggests that this mode of knowledge development, reliant on both experience and communication, is placed in some doubt within the context of the Pacific because of the constraints of "smallness", "isolation" and "resistance to change".

To gain answers to such questions, discussion in previous chapters has directed this investigation to the site at which engineers carry out their work on machines and equipment - within the organisation. The case study accounts detailed in this and the next two chapters, focus on the experiences of engineers working with the globally established technology of radio broadcasting. The organisation under scrutiny is a public radio station in the Pacific country of Samoa. There is surprisingly little information about engineers working in organisations of the Pacific region. The details of the research design discussed next are aimed at correcting this deficiency in the literature.

5.2 RESEARCH DESIGN

The research design complements an interpretative case study research methodology as explained in Chapter 4. To enable a better understanding of the factors which motivate and dissuade a small group of Pacific Island engineers in their problem solving endeavours within their organisation, the research design responds by satisfying the need for two types of information: information relating to the influence the organisation has on the engineers' work and information concerning the influence the machines and equipment have on the engineers' work. The two types of information are combined in the following analysis to provide an understanding of how the organisation, the broader physical and social environment and the broken machine, contribute to the experience of problem solving for the engineer.

Information gathering consisted of document analysis (reference and equipment manuals, log books, magazine, journal and newspaper articles), participant observation within the organisation and formal interviews with outside agents. In formal interviews and participant observation, the making of field notes was the method of information recording. These notes were subsequently expanded into continuous prose and annotated with further comments and reflections, clearly denoted so as to separate these from the field notes.[1]

The organisation of these three chapters mirrors the three issues ascertained from the literature review as central to understanding technological capability development in the Pacific region: this chapter seeks to determine the significance of problem solving to the engineers (question 2); chapter 6 investigates the influence the organisation has over problem solving (question 3); and chapter 7 looks at the uncertainty over the factors which shape the organisation and draws conclusions about the influence local society has in the development of technological capability (question 4 and question 5 respectively).

[1] See Appendix 2.

My two week visit to conduct this research is set against my previous involvement with the broadcasting organisation over an eight year period (see Preface). Initial contact with the organisation was an intensive four year period (1990-1994) as a contracted technical adviser. Good rapport was built with many staff, strengthened considerably through the shared experience of a devastating cyclone in December, 1991. Suffice to say, that access to the organisation was facilitated by this previous association which inevitably shapes my understanding of the events described in this study. This research was also supported by the regional broadcasting body, the Pacific Island Broadcasting Association (PIBA).[2]

5.3 THE RESEARCH

The analysis in the literature review advances the idea that an appropriate means by which to view the endeavours of engineers is essentially one of mediation between the machine and the organisation. In order to begin focussing on questions about factors which contribute to the experience of problem solving for the engineers, it is first necessary to situate the engineer within the broader context of the organisation and the community. To that end, the commentary begins by building an appreciation of what the organisation considers important, what the engineers consider important and what the engineers do in this organisation.

The following descriptions, compiled from my field notes and documentary sources, identify a number of factors which contribute to an understanding of how the engineers and the organisation "fit together". The commentary begins with the journey from the airport to the radio station on the day of my arrival. Its purpose here is twofold: to

[2] See Appendix 1.1

introduce the detailed descriptions of the radio station with an illustrative account in order to give the reader some feeling of how the environment and the radio station relate to each other; and to identify what appeared to be uppermost on the chief engineer's mind as a way of becoming better acquainted with the issues the engineers perceive as important.

5.3.1 The Organisation.

The journey from the airport to the radio station, which is about 40 kilometres, is recognised as an appropriate introduction to first time visitors because they are presented with a variety of images which reflect many aspects of life in Samoa. Accordingly, these same features can be related in some way to the radio station's function in this community. The road follows the coast for the best part of the journey. The brilliantly blue Pacific Ocean pounding on the coral reefs a couple of hundred metres out from the shore line on the left and the mountains which rise steeply from the coast on the right represent two dominant technical challenges for radio broadcasting, as is the case in many countries of the Pacific. The villages through which the road passes characterise, in large part, the social and cultural interests of the "listening public". The churches, like monoliths next to the more humble dwellings of traditional thatched "fales" and European styled houses of these villages represent an influential constituency the radio station serves. Similarly, the traditionally styled Parliament House building near the end of the journey, symbolises a more potent form of interest the radio station serves - that of government.

Drawing associations between these dominant physical features and the radio station serves the purpose of illustrating the variety of functions broadcast technology facilitates in Samoa today. Initially established in 1947 for the use of colonial administrations to

broadcast weekly messages from the governor[3], coming to a definitive description of what purpose the radio station serves today is confounded by the diversity of information types broadcast: parliamentary broadcasts, personal messages or telegrams, alterations to shipping and aviation schedules, public notices from government, business advertisements, funeral and birthday announcements, religious and other public affairs programming, requests for blood donations as well as weather reports, local news and overseas news broadcasts from short-wave services such as Radio Australia and Radio New Zealand. This list is not exhaustive. As the coverage area of the radio station extends to the neighbouring United States administered territory of American Samoa, radio has also been of benefit in maintaining familial and cultural ties of a people who were politically separated under the auspices of Germany, Britain and the United States at the turn of the century (for example, see Ramese, 1999; Sagapolutele, 1998;).

Despite increasing telephone penetration rates and the publication of a daily newspaper, there are still a number of needs these communication mediums cannot cater for.[4] The low cost of receivers coupled to the immediacy which radio broadcasting affords makes it an efficient and responsive medium for communicating information of mass appeal such as weather reports during the wet season when cyclonic activity is high (for example, see Ramese, 1999; Seward, 1998). The live broadcast of events, such as rugby matches, church or school anniversaries and Independence Day celebrations, is considered an important aspect of the radio station's function in the community.

Both western and local music is broadcast by the radio station. A regime has been established where brackets of set time duration (20 minutes) are devoted to playing western and local music alternatively during the day. Music with words in the vernacular but, sung to a popular melody of western origin, is generally played in the local music bracket. In the evening, locally-produced music is played exclusively on the public radio.

[3] See Appendix 1.2 for profile of the radio station based on the recollections of a former manager.

[4] Out of a population of 160,000, radio set ownership in 1993 was 117 per 250 capita. This compares to television set ownership of 42 per 1000 capita, telephone access of 43 lines per 100 households (SMEC).

Announcements are both in the vernacular and in English with the exception of the evening programmes which are wholly in the vernacular. As the subject matter of evening broadcasts is dominated by issues of local interest and considered not of interest to the expatriate community, another frequency is devoted to English programming in the evening. This alternative English-only programming is also broadcast on Sunday, when the main channel broadcasts religious programming in the vernacular. Every weekday morning during school term, this second frequency is used to broadcast a one hour schools programme produced by the Education Department. During Parliament, its purpose is to fulfil the constitutional requirement for the broadcast of an English translation of parliament in tandem with actual proceedings broadcast on the main channel.

The granting of a radio broadcasting licence to a private concern in 1989 represented the first of a number rival stations, albeit, on the FM band. The robust nature of AM signals in terms of the prevailing geography of high mountains however ensures that public radio has coverage over a greater portion of the country. A capital grant of a new transmitting facility, provided in the late 1980s by AusAID, the development arm of the Australian Government, is powerful enough to even reach islands some 500 kilometres away (for example, see Seward, 1998). In contrast, the FM stations have coverage over only the more highly populated areas of the country, including the city precincts. In order to achieve a comparable coverage to public radio, stations on the FM band require many transmitters to cover the "nooks and crannies" of the mountainous terrain - a capital investment arguably beyond the means of the private concern.

Staff working at the radio number twenty two. The organisational structure of the radio station reflects divisions normally employed in radio stations - a technical section (4 people), a programmes department incorporating journalists and announcers (8 people), an advertising department incorporating accounts staff (4 people), and an executive

management, consisting of the Manager, Administration Assistant and an adviser on cultural matters. Ancillary staff, such as the driver, tea attendant and night watchman, are responsible to the manager but also are directed by section heads. All the positions, except for the Manager's position, are wage and salaried government positions which are administered by a central personnel authority of government. The manager's position is by appointment under contract by the Minister of Broadcasting, who also fulfils the role of Prime Minister.

5.3.2 The Engineers.

Employment at a radio station means for these engineers that much of their lives are dominated by the need to maintain the transmission of programmes. This fact became quickly apparent as we left the airport to begin our journey to the radio station. Conversation with the chief engineer was initially stalled because he was distracted by the vehicle's radio. He was listening to the radio not so much to hear what was being said but to confirm that the station was still on the air. Later the chief engineer remarked that this was one of the disadvantages of his job - he is expected to keep an ear to the radio continually, even during the evenings and on weekends.

Conversation during the journey was characterised by a lively exchange of information with the need for further staff training to be the first subject raised (and often discussed in conversations with the engineers and other staff during my visit). The chief engineer told me that two members of the technical section had recently been on overseas training courses. The senior operator had attended a three month audio engineering course in Japan while the technician had been to Malaysia for a four week course on audio tape recorder alignment. Noting that he didn't take the opportunity to nominate himself for this training, the chief engineer comments:

"I like to give these guys the opportunity to learn more, that's why I sent them".

The chief engineer is a qualified broadcast engineer who attained exemplary results four years previously in an electronics engineering certificate course he undertook at an Australian Technical and Further Education College (TAFE) under a scholarship funded by AusAID. His attainment of a further qualification while he was in Australia, the Broadcast Operator's Certificate of Proficiency (BOCP), mandates a capability to undertake the role of broadcast engineer as either qualification was considered sufficient by the communication regulations of Australia at the time.[5]

The technician also won a scholarship to undertake the same course with the chief engineer but after achieving commendable results in the first year, was unable to complete the course due to reasons unrelated to his academic ability. The senior operator has had over 25 years experience in radio broadcasting and has attended a number of short training courses but has never achieved any formal qualifications. The only other member of the technical section, the trainee, has completed a technical diploma course at the local polytechnic. The chief engineer says he would like to organise a scholarship for the trainee but also wants to give the technician a second opportunity to complete his course of study.

An important aspect of the chief engineer's work is fixing equipment faults. The chief engineer finds the administrative responsibilities of running the technical section, (responsibilities he took on soon after from returning from his studies overseas), have denied him the opportunity to gain practical experience. The chief engineer remarks:

[5] The Broadcast Operator Certificate of Proficiency (BOCP) was a government conferred qualification denoting an individual's ability to manage the technical aspects of a radio station. A representative from the Australian Communications Authority (ACA) stated that with industry self regulation, the responsibility for determining minimum levels of qualifications had been given to industry bodies. A representative from the Australian Broadcasting Authority (ABA) stated that possession of a BOCP, while not being a mandatory requirement for the granting of a broadcast transmitter license now, is still regarded as a suitable indicator of technical competency.

> "I really miss not working on the bench with a multimeter and getting to really know the equipment".

From this, it is clear that the chief engineer sees his role as primarily one of equipment fault finding. He is the most qualified and, whether by virtue of these qualifications or his position as chief engineer, ultimately has to bear the responsibility for any equipment failures.

Conversation turned to the live broadcast of the recent South Pacific Mini Games in American Samoa. The engineers had established a radio frequency link from the games venue so that the commentaries could be broadcast live. In view of the distance covered by the radio link, the chief engineer saw this latest broadcast as the most recent culmination of their outside broadcasting capability, something the rival FM station wishes to emulate, as a latter conversation with its manager revealed. Despite the mountainous terrain of the country's interior, the radio station has over the years developed a capacity for carrying out live broadcasts from many distant locations - experience which was initially grounded in the live broadcast of weekly church services.

Interestingly, on arriving at the radio station, I noticed the aerial used for the live broadcast of the games was still standing, secured with rope to the disused tank stand next to the radio station building. The chief engineer explained to me that he was still experimenting with it to see if he could receive a signal direct from the neighbouring island of Savai'i. As programme material from Savai'i is broadcast every day, the broadcasts are sometimes interrupted because of power failures to the repeater on a nearby mountain which relays the signal from Savai'i. Having the ability to receive this signal directly from the studio at Savai'i would make life a lot easier for him. It appears that the process of developing further expertise in outside broadcasts is ongoing and is an example of incremental innovation, which commentators such as Bell and Pavitt (1993,

p. 160) describe when technologies are adapted to the local conditions of developing countries.

The initial conversations suggest three different elements to the chief engineer's experience: firstly, the need for further training; secondly the centrality of fault finding to his work; and thirdly, by his reference to live broadcasts, the importance of providing programmes to the listening public. As will be described in the next section, these three issues are interrelated and hinge on the central task of problem solving.

5.5.3 The Engineers at Work: Problem Solving.

The two places in which the engineers do most of their work are the radio station studio, (a weatherboard building, constructed in the 1940s for the station's opening), and the transmitter building, (a concrete building erected as part of the transmitter project funded by AusAID in the late 1980s). Both buildings contain the studio and transmitting equipment which, along with the transmitting mast in the adjoining paddock, makes broadcasting technically possible. In terms of determining a response to research question 2, "what factors can be identified as contributing to the experience of problem solving for Pacific Island engineers", there is much information which contributes to an understanding of this question in these two areas where the engineers work.

The chief engineer's office is part of the central equipment area and also contains most of the printed information resources. The printed information resources are made up of equipment manuals, college text books, industry journals and magazines. These manuals and college text books are necessary for the operation and maintenance of equipment as their purpose is to describe the inner workings of machines and equipment. Industry magazines and journals, on the other hand, serve the purpose of informing the engineers

about the latest developments in broadcast equipment design from which they are better able to determine future equipment needs.[6]

Adjoining the central equipment area is the store room which houses an assortment of working and broken equipment and spare parts. The general appearance of this room is cluttered and disordered, as is the workshop in which the technician, senior operator and trainee work. This room has three benches with a number of cupboards to store equipment and cables. The two areas serve different functions, as explained to me by the chief engineer.

The equipment in the workshop is used regularly for outside broadcasts or when a public address system is required for public functions. The spare parts and equipment in the storeroom are used to overcome equipment failures. In the majority of failures a working spare is available which can quickly takes the place of the faulty unit. On re-establishing normal operations, the faulty equipment is then investigated. If a faulty component is discovered, spare parts are sought from the storeroom. As local hardware and electrical outlets have very limited stocks of electronic parts on hand, if a part is not available from the spares cupboard the engineers are usually required to purchase these parts from overseas, a time consuming process which can take six weeks or more. This explains why so many items of old equipment are retained - it is a practical response to their poor access to spare parts.

The significance of problem solving to the engineers is better appreciated from the descriptions given in conversations, which are often dominated by the topic of equipment faults. Such was the case when the chief engineer took me to the transmitter building to show me the transmitters. As the transmitter system is the most crucial part of radio broadcasting, the potential for failure here distinguishes the transmitters as potentially the most problematic. The size of these capital items are not appropriate for fitting into a box

[6]See Appendix 2 (Day 6) for more detailed descriptions of printed information sources.

for dispatch to the manufacturer for repair - so when the transmitter breaks down, the engineers *must* repair it. The transmitter building houses three identical transmitters: Transmitter 1 and 2 are set to the same frequency and are used for the main programme in a main/stand-by mode. Transmitter 3 is set to another frequency and fulfils the role of providing the supplementary English-only programmes, including translations of parliamentary proceedings and school broadcasts. In view of the transmitters' importance to the radio station, much of my attention was devoted to understanding the transmitter faults which had, or were, presenting difficulties to the engineers.

Orr (1996) perceives a social and a technical dimension to the work performed by the technicians of his study. When analysing discussions about equipment faults, it is possible to similarly perceive a social and a technical dimension to the problem solving these engineers carry out. In one example, the chief engineer told me of the problems he had had with the RF Drive circuitry of the parliamentary broadcast transmitter (Transmitter 3) which, by his account, caused considerable stress. He told me that while the failure of this transmitter did cause some concern initially (as it prevented the broadcast of school programmes), the repair of the transmitter became of critical importance when it was announced that parliament would be convened for sittings. The chief engineer worked throughout at least one night to find the cause, discovering just hours before parliament was due to begin, that the problem lay with the apparently simple cause of a blown fuse. His reaction to this anti-climatic end were contained in comments he made to me:

> "It was the .....fuse all the time. When I put a new one in it all started to work. I walked to the office, told...[the manager]..., jumped in my car and went home to sleep".

As the chief engineer related, his frustration was derived from the fact that he had checked the fuse as a first step by taking a resistance measurement which suggested it was still in

tact. After taking a time consuming detour checking other parts of the circuitry, he said that he measured the fuse a second time, this time removing it from its holder. It was then that he discovered that it had, in fact, blown.

The technical dimension of the problem with the parliamentary transmitter is apparent in the details about the RF drive circuitry and the ultimate discovery of the blown fuse. Yet, the relief of the chief engineer at discovering the problem and completing the repair seems to be only partly explained by his satisfaction at overcoming a technical challenge. The actions of the chief engineer can also be related to the manager's concern over the broadcast of parliament which in turn required him to work throughout the night, revealing a social dimension from which incentive to repair the fault is also found. In a subsequent conversation with the manager, she revealed that the failure of the parliamentary transmitter was of considerable consequence to her as the person ultimately responsible for the broadcast of parliament. Because parliamentary broadcasts are popular with the general public (and also a constitutional requirement), the failure of the transmitter was a potentially embarrassing problem to her and the engineers She admits to having doubts that the opening of parliament would proceed as scheduled when, after receiving assurances from the chief engineer that all was in hand, on leaving the studio later that night, she noticed the lights at the transmitter building ablaze and vehicles from the local telecommunications company parked outside. Knowing the potential impact this fault had on the organisation, allows one to see how this is translated into demands from the organisation that determined the priorities to which the chief engineer worked. It is clear that the social implications of the problem contributed significantly to the experience of the chief engineer in resolving this problem.

Analysing another situation reveals a different perspective on the social and technical dimensions of problem solving. I had noticed during the visit to the transmitter building an "Envelope Error" fault indication showing on the back-up transmitter (Transmitter 2). On asking about this fault, the chief engineer told me that the Envelope Error indication

had been of concern to him as the station was without a back-up transmitter - should the main transmitter (Transmitter 1) fail, the station would be unable to broadcast. He told me that he found an overheated integrated circuit (IC) which he had replaced. The insertion of the new IC did not resolve the problem and he asked me to "...go over..." the problem with him. I recalled that this fault had been the subject of a telephone conversation I had had with the technician six months previously, so I was surprised to notice that the fault had not been fixed.[7] In contrast to the problem with the parliamentary broadcast transmitter, the Envelope Error fault in the back-up transmitter (Transmitter 2) was not raised by the manager in the later interview. The social and technical dimensions of this problem can be seen in the time it has taken for the fault to addressed. As it was not interfering with normal broadcasts, an absence of demand from the organisation combined with the technical complexity of this fault had allowed the fault to languish for some months.

Another incident which the chief engineer related to me reveals another aspect of the experience of problem solving. In this case low technical complexity and high organisational demand combine to create this particular experience. The engineer told me that he was once called in from sick leave to attend to a problem concerning the transmitters - the station was off the air but no one could find the reason why. He discovered on his arrival that the processing amplifiers had been inadvertently switched off. (The trainee was subsequently found to be responsible for this when he was recording maintenance data - he thought he was switching a monitoring speaker off which has no direct role in supplying programme signal to the transmitters). From the perspective of the organisation, this problem had a similar effect as the failure of the parliamentary broadcast transmitter (Transmitter 3) in that both represented off-air situations and were likely to lead to high degrees of public scrutiny. The only difference was that in this case the solution was simply switching the processing amplifier back on.

[7] See Appendix 1.3.

These three transmitter faults detailed so far have been summarised in Table 5.1. It can be seem that tasks which are perceived as being of maximum difficulty and drawing most on the engineer's emotional resources are those in which both technical complexity and organisational demand are high, such as the failure of the parliamentary broadcast transmitter. The failure of the stand-by transmitter and the inadvertent shut down of the transmitter processing amplifier are less demanding. The low organisational demand of the former has allowed other priorities to overshadow the need to solve this problem. The combination of low technical complexity and high organisational demand of the latter is arguably most preferable of faults because the timely manner in which the repair was affected in the context of crisis translated into maximum kudos for the chief engineer.

Another task detailed in Table 5.1, the repair of cables, representing both low organisational demand and low complexity, is a job that the technician and trainee were observed carrying out. In this task, action is taken in anticipation of the organisation wanting a working cable sometime into the future - one example of preventative maintenance the engineers employ. While there is a certain degree of skill required to make sure the cable does not break the first time it is used, cable repairs are viewed here as being an activity of low complexity (the technician was able to relate his experiences at the training course in Malaysia while carrying out this task) and so, one usually reserved for the technician or the trainee.

Development of the engineers' outside broadcasting capability, detailed earlier in the introductory accounts, is another aspect of their work which can be understood in terms of the social and technical aspects of problem solving, as reflected in Table 5.1. It is an activity in which the frontiers of what is possible in outside broadcasting are being gradually extended. Much of the work of the engineers in this area is aimed at overcoming the local geography of high mountains and large areas of water as they strive for the coverage of events at ever increasing distances from the town precincts. While it

Problem Solving Example	Organisational Demand	Technical Complexity	Attributes of Problem Solving Experience
Parliamentary Broadcast Transmitter - RF Drive Fault	High	High	Working under the pressure of a deadline; Difficulty in determining nature of fault; Required to work throughout the night.
Back-up Transmitter - Envelope Error Fault	Low	High	Difficulty in determining nature of fault; No pressure from organisation; Fault left to languish as other priorities pursued.
Transmitter Processing Amplifier Mistakenly Turned Off	High	Low	Working under the pressure of an immediate deadline; Little difficulty in determining nature of fault; Generates maximum kudos with minimum of effort.
Cable Repairs	Low	Low	No immediate time limit imposed by organisation; Requires a moderate degree of skill but is not complex; A boring but necessary task.
Developing Outside Broadcast Capability	Moderate	Moderate	Enjoyable because land and sea typography poses challenges which use and extend both technical and local knowledge; The nature of this knowledge is formative so organisation is supportive but unable to impose specific demands.

The Problem Solving Experience of the Case Study Engineers

Table 5.1

is clear the organisation is generally oriented to the goal of outside broadcasts, the development of the engineers' outside broadcast capability is a formative process of extending current knowledge through experimentation in which demand from the organisation has not been fully defined or expressed. The combination of a generally supportive atmosphere and a moderate degree of complexity makes the development of outside broadcast capability an activity most members of the technical section enjoy, as demonstrated by the pride in successfully conducting the outside broadcast of the Pacific Mini Games in America Samoa.

It can be seen then, that the work engineers perform has significant social implications by virtue of the machines and equipment which mediate the function of the radio station in the broader community. The technical failure of a radio station is a very public occurrence, so the issues of concern to engineers are wider than the immediate technical imperatives of humming machines and blinking lights. Indeed, the satisfaction the engineers gain from instances such as successful outside broadcast events suggests that much of the impetus to their work is derived from the positive impact their actions have on the broader community.

Hence, the significance of problem solving to the engineers can be explained by a combination of the social demands expressed by the organisation and the technical complexity of solving equipment faults. The successful repair of a failed component may be considered an achievement in an engineering sense, but the fact that an important social contract between the broadcasting organisation and the community is repaired argues strongly in favour of an analysis which places engineers firmly within the morass of the social processes of local society. This aspect of the engineers' problem solving is considered further in Chapter 7.

The second aspect of the engineers' problem solving is technical complexity. Determining an absolute measure of complexity is problematic as the descriptions reveal

that a number of factors are involved. The earlier example of the transmitter amplifiers which were inadvertently switched off suggests that complexity is a subjective experience - while the chief engineer had little difficulty resolving the problem, the other technical staff floundered. One could compose a scale for individual members of the technical section, each containing different representations of difficulty on the basis of their differing ability to respond to complexity. The next chapter, chapter 6, investigates the experience of technical complexity in more detail.

5.4 CONCLUSION

This chapter was primarily aimed at analysing the significance of problem solving to the engineers. After introducing both the engineers and the organisation, the commentary looked at the resources available to the engineers to determine that these resources were primarily aimed at problem solving, particularly the task of fault finding in broken machines and equipment. The analysis then went on to investigate the circumstances surrounding significant faults with the broadcast transmitters as well as less important problems. From this investigation, it was concluded that the experience of problem solving for the engineers was influenced by two significant factors. The first was the demand placed on the engineers by the organisation. These demands were found to be a reflection of the social purpose of the radio station. In times when equipment failure threatens the ability of the organisation to fulfil this role, the social demands on the engineers are greatest. The other significant element to the problem solving experience of these engineers is an individual's ability to respond to technical complexity. In combination, these two elements contribute significantly to the experience of problem solving for these engineers.

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Chapter 6

Understanding Complexity: Problem Solving From An Information Perspective

6.1 INTRODUCTION

The purpose of this chapter is to focus on one aspect of the problem solving that the case study participants undertake, technical complexity. To that end, the analysis is directed at further illuminating the principal research question of how the engineers solve problems within the context of "smallness", "isolation" and "resistance to change". More specifically, this chapter responds to the issue judged important by the analysis of literature which identifies the organisation as playing an influential role in the development of technological capability. Therefore, to better understand the problem solving these engineers undertake, the chapter responds to question 3, "in what ways does the organisation facilitate or constrain problem solving?".

In coming to an understanding of the complexity associated with fault finding, the analysis focuses on the role of information as an important resource in the resolution of equipment faults. A basic tenet of Macdonald's information perspective is to associate the process of change with information. While minor change may be answered by existing information within the organisation, the greater the complexity of change, the more likely information from new sources outside the organisation, will need to be found. The following analysis suggests that the engineers' experience of complexity is best understood in terms of the difficulties they have in coping with a deficiency of

information during problem solving. The chapter argues that the task of making up for this deficiency of information is confounded by barriers constraining access to problem solving information outside the organisation. The chapter argues that the dynamics of relationships within the organisation and those outside with equipment suppliers are significant in constraining access to problem solving information.

In order to develop a keener awareness of these issues, the next section describes the repair of the back-up transmitter (Transmitter 2) which is subsequently used as an example to explain how the experience of complexity is related to overcoming deficiencies in information.

6.2 AN EXEMPLAR OF FAULT FINDING

It will be recalled from the previous chapter that the fault finding efforts of the engineers to solve the problem with the back-up transmitter (Transmitter 2) centred on an overheated integrated circuit (IC). The replacement of this part with a new one did not solve the problem. The course of events leading up to this point is notable for a number of contradictions between statements in the manual and the actual symptoms displayed by the transmitter. One such example concerns the trouble shooting procedure associated with the an Envelope Error fault. The equipment manual states that the presenting problem of an Envelope Error indication suggests that the transmitted signal is distorted (Harris, 1994, p. 6/11). The cause of this distortion is not considered serious enough to damage the transmitter so, for the purposes of fault finding, assumes that the engineer is able to switch the transmitter on. However, the engineers found that the transmitter would not switch on. This eventuality is not dealt with by the manual with regard to an Envelope Error fault. The manual does detail procedures to look at this symptom in another context but reveals a number of possible causes, none of which appear to be

related to the circuitry associated with an Envelope Error fault (Harris, 1994, pp. 6/2-6/3).

How the chief engineer found one regulator integrated circuit (IC) to be excessively hot is explained by his discovery of another fault indication which was illuminated inside the transmitter on a circuit board called the Controller Board. This fault indicator signals a regulator failure. As the fault indicator does not specifically indicate which component is at fault, the chief engineer was still required to conduct an ad hoc check of components for excessive temperature using his finger as a "rule of thumb" temperature probe through which he found that one of the regulator ICs was very hot.

Still, the Controller Board problem appeared to have no specific association with an Envelope Error fault. The Controller Board's main function is to control the operation of the transmitter. The function of the Envelope Error indication is to alert the engineers to excessive distortion in the transmitted signal. However, the discovery of the second fault indication on the Controller Board and the overheated IC seemed more in line with a condition where the transmitter would not switch on, so the chief engineer decided to contact the distributor in Australia to begin the process of ordering a new IC. The subsequent ordering and arrival of a replacement IC some weeks later did not solve the problem as the new IC was found to be overheating also. It appears that the chief engineer reached a dead end at this stage because he did not detail any further work he had performed when he asked me to go over this problem with him.

It is worthwhile reflecting on the chief engineer's predicament: two fault indication lights suggesting contradictory causes and a trouble shooting procedure which did not provide the engineers with any clear direction. As I had come across a similar fault with this model of transmitter previously, I thought that the over heated IC indicated a problem similar to my earlier experience - a faulty component drawing too much current through the IC.

When the engineers and I began to work on this fault, initial efforts were directed at determining whether my earlier experience of the problem was relevant to this problem with the Envelope Error fault. This was done by measuring the resistance of the load at the output of the IC to assess whether too much current was being drawn. It was found that the resistance on the output of the IC was about eleven (11) ohms. This had also been noted by the technician in his investigation, but he did not know whether this represented a fault condition. I did not know either as the reading did not represent a short circuit in a theoretical sense, that is zero (0) ohms. As the IC supplied a number of components on the Controller Broad, as well as components on two other boards, the exercise of calculating the combined resistance of all these components was beyond the capabilities of both the engineers and myself. Besides, the alternative method proved to be far more time effective. As the parliamentary broadcast transmitter (Transmitter 3) was not being used, it was decided to take a resistance measurement at the same point where we measured the eleven (11) ohms on the faulty back-up transmitter (Transmitter 2). After removing power from the parliamentary broadcast transmitter (Transmitter 3) we measured a resistance of thirty (30) ohms suggesting that the eleven (11) ohms measured earlier pointed to an actual fault with the back-up transmitter (Transmitter 2).

Problem solving then was directed at isolating the cause of this low resistance. After disconnecting the other boards which were connected to the Controller Board, the resistance of 11 ohms remained, suggesting the problem lay on the Controller Board. I identified a number of components on the circuit diagram to be checked and the technician set about removing the Controller Board in order to de-solder these components to individually check their resistances. A faulty capacitor was eventually identified but a replacement was hard to find. Even though such a component is freely available from electronic parts stores in Australia for a nominal cost, no such part was available from local outlets. Approximately one hour was spent going through boxes of components and spot checking boards from old equipment in pursuit of a component which matched

the specifications of the faulty part in both capacitance and physical size. When one was found, the board was re installed and the transmitter was brought back to life. Armed with the knowledge of the nature of this problem, another look at the circuit diagram revealed the relationship the hot IC had with the Envelope Error indication. The IC provided power to the circuit which controlled the indicator light, after following a path through a number of pages of the circuit diagrams. The Envelope Error light was displaying a fault which did not exist.

6.3 IN WANT OF INFORMATION: THE IMPORTANCE OF EXTERNAL INFORMATION.

The previous account highlights a number of factors which contribute to the complexity of problem solving. Significant was the uncertainty surrounding the existence of two fault indications and the absence of direction from the equipment manual to cope with this anomaly - the trouble shooting procedure pertaining to the Envelope Error fault indication was unable to provide any useful direction after step 1. From there, a number of methods of eliciting information were undertaken - the making of visual and tactile observations, the taking of voltage and resistance measurements, making qualitative judgements about voltage and resistance measurements and undertaking comparisons with other working machines. All contribute to an information gathering process which includes inductive methods of problem solving along with deductive methods. While the equipment manual is clearly an essential information resource, closer analysis of what information the manual actually provides suggested that there were significant gaps in this information that the engineers were required to fill.

Why the manual is unable to provide all the information necessary to repair the transmitter is best understood by looking at what information the manual provides (Harris, 1994).

In order for the engineers to gain an understanding from the schematic diagrams of how the circuits should work, they need to have knowledge of the implied voltage and current distributions indicated by symbols signifying different components (resistors, transistors, capacitors and so on). While these voltage and current distributions follow established principles, such as those in Ohms Law and transistor operating principles, the exercise of defining the nature of these distributions is complicated when there are a number of interconnected components. Even though the diagrams detail voltage measurements at selected nodes of the circuit, it is impractical to detail every node voltage, meaning that engineers must develop a picture within their minds of how these voltage distributions are composed throughout the circuit, based on their knowledge of how these components behave under different conditions.

Moreover, this understanding applies to a working transmitter, not necessarily to the broken transmitter. The interconnected nature of these circuits means that a failed component can have unpredictable knock-on and feedback effects capable of not only altering its own distribution of voltages, but also those of the components connected to it. As well as developing a picture of how the circuit is meant to function, the engineers must have knowledge of the possible effects a broken component may have in altering the dynamics of the circuit. The taking of measurements at different points is therefore aimed at eliciting anomalies between those measured and the voltages detailed and implied in the circuit diagram. On the basis of these perceived anomalies, alternative scenarios can be constructed based on the likely effects faulty components will exert on the voltage distributions of the circuit.

This process is made more complicated by the knowledge that other components may also fail as a result of the initial fault because they are subjected to excessive currents or voltages. The significance of such a situation is apparent in the over-heated IC. So, in some cases, the transmitter instigates its own protective measures, such as stopping the transmitter from being turned on, which further reduces the avenues from which to elicit

information about the faulty transmitter. Such are the altered characteristics of the faulty circuit, a broken transmitter presents a puzzle whose characteristics are quite unlike that described by the equipment manual.

It is apparent from these descriptions that the codified information sources at the engineers' disposal do not contain the full complement of information required to answer the problematic situation. In contrast to more accepted notions of problem solving, where the equipment manuals are viewed as containing all the information the manufacturer determines to be necessary to repair faults, these descriptions of fault finding suggest that there can be considerable difficulty in establishing the cause of the anomalies between what is implied in the circuit diagram and the observations made of the broken machine. The experience of learning-by-doing is hence found to be a slow and uncertain process, where the end-point is never known until the machine is confirmed to be working.

It can be seen that the puzzle metaphor Macdonald uses is effective in revealing the difficulties of the case study engineers. The missing piece to the puzzle is the information which relates to the faulty component which is difficult to define in terms of its location and "shape" (component type). This situation is essentially at odds with the certainty the organisation expects from its engineers. The picture which emerges from these descriptions, is that of the engineers being caught between the intransigence of the machine in not yielding information about its current state, which is nevertheless exacting in the solutions proposed for it, and the organisation, which requires a functioning machine in order to fulfil its obligations to the community.

If the engineers decide to seek outside help, the uncertainty which dominates the experience of problem solving precludes any clear definition of the problem by which the engineers are able to specify what information they require. This is apparent in the facsimile that I sent to the technician concerning the Envelope Error problem in response

to a telephone call seven months prior to my visit.[1] If one views the response, it is clear that I am referring to a circuit in another part of the transmitter (I did not have equipment manuals to refer to). Reference to an earlier cyclone was intended so that he could look the relevant fault up in the log book I kept while I was working at the radio station. The difficulty the technician had in defining what his need was is reflected in the different messages I delivered hoping to satisfy his need for information. Knowing what the ultimate cause of this problem was, it can be seen that the final advice that I had delivered by facsimile (about checking for shorted capacitors) was indeed correct. At the time, however, none of these messages seemed to make sense to the technician as he was unable to make productive use of any of the options I presented to him.

There is good reason to associate the missing complement of information with the tacit component of technological knowledge. As tacit knowledge is viewed as knowledge that has not been articulated, the fact that there is much information which has not been articulated in the manual, establishes an obvious association between this missing information and tacit knowledge. In seeking explanations of why this knowledge cannot be articulated, one need only consider the number of possible combinations of component failures which would make the codification of each of these scenarios in a trouble shooting chapter an onerous, if not impossible, undertaking. Add to this the particular uncertainties introduced by the unique environment of the radio station, such as a gecko lizard becoming entangled in the high voltage portions of the transmitter, the manual writers are further constrained from accounting for such situations as they are largely ignorant of such possibilities.

Examining nature of the information I was able to bring to the repair of the back-up transmitter, it can be seen that its source was my earlier experience with an identical transmitter. The nature of this missing component of information can therefore be associated with that which was derived from experience, another attribute of tacit

[1] See Appendix 1.3.

knowledge. However, while there is a recognition that more has to be learnt - as reflected in the number of times the need for further training came up in discussion with staff members - this is largely perceived in terms of theoretical knowledge. This suggests that problem solving and experiential knowledge development is seen by staff members as sharing a linear relationship with theoretical knowledge, along the lines described in Enos's (1991) study, rather than being a distinct activity designed to illicit information about the many "unknowns" from the machine which cannot be described by the manual.

Comments made by participants of the Audio Engineering Course the senior operator attended in Japan suggest that course designers similarly perceive the relationship between theory and practice in linear terms. In a document containing participants' feedback about the course, considerable frustration was expressed at the theoretical nature of the course. Out of the seven people who attended, five made reference to the need for more information relating to the practical difficulties of repairing and using equipment. In the course material that I surveyed there was an obvious emphasis towards mathematics and formulas. While this is not a basis for criticism in itself, the relative lack of balance in terms of practical training was most apparent. While there is an inherent difficulty in articulating such practical knowledge for the purposes of a course (that is, knowledge which is difficult to articulate) there is also good reason to believe on the basis of the participants' feedback that the demand for tacit knowledge development exists and is not being met in such courses. This raises the question whether similar attitudes have been responsible for poor appreciation of the importance of communication among engineers as a necessary element to their capability development.

In his study of photocopier technicians, Orr (1996) attaches considerable significance to the idea of groups of experienced engineers collectively responding to the uncertainties associated with machines and equipment. From Macdonald's (1998) perspective, there is good reason for this. The prime difficulty for the problem solver is defining the missing piece of information needed to solve the puzzle. Macdonald describes this difficulty as

having to know what one does not know. Information networks respond to this difficulty of the information seeker by promoting the transfer of problem solving information. The more focused the areas of common interest are among members of an information network, the more likely individuals will have an understanding of the information others are likely to need (Macdonald, 1998, pp. 20-23). Significantly, information networks based on more informal alliances, such as friendship and trust, are viewed as being best for transferring "difficult-to-get" information such as tacit knowledge.

If one reflects on the story telling of engineers described by Orr (1996), there is reason to associate the lack of participation of the radio station engineers in such networks with the difficulties they have in making up for the deficiencies in information, particularly that related to tacit knowledge. For example, the chief engineer, in expressing his frustration at the lack of experience of his colleagues remarked to me:

> "I can't rely on those other guys to help me - I have no one to discuss difficult faults with".

Relationships with engineering staff in other organisations are a means by which networks of communication with other experienced practitioners may be formed. Their is, for example, active informal communication and cooperation between engineers of the radio station and those of other media organisations such as the television station, university media units and youth departments (though, interestingly, not the radio stations which are in direct competition). The presence of telecommunications company staff during the crisis with the parliamentary broadcast transmitter, though not officially sanctioned by either department, provides another indication of the chief engineer's need for contact with other experienced practitioners, or at least, the use of their test equipment. While contact with engineers from other organisations is viewed here as a positive indication of problem solving potential, it must also be noted that the practical

expertise these people are likely to bring to the problems associated with high powered transmitters or professional tape recorders, is of limited relevance.

On the other hand, there is little contact with organisations which could be reasonably viewed as potentially rich sources of problem solving information, such as other radio stations or overseas equipment suppliers. It is noteworthy that the engineers did not contact the transmitter manufacturer during the failure of the back-up transmitter (Transmitter 2) or during the problem with the parliamentary broadcast transmitter (Transmitter 3). This is despite the existence of both phone and facsimile numbers for a 24 hour technical help service. Another poignant example of the lack of contact these engineers have with other practitioners overseas is seen in the loss of contact the chief engineer has had with a friend in Australia who attended college with him. The engineer related to me that he once was asked to be the best man at his wedding some years ago. Over time, contact has waned and he has not communicated with him even though his Australian friend now manages an electronic spare parts shop. The limited participation these engineers have in networks with experienced others suggests a serious problem in gaining problem solving information, particularly that from experientially derived tacit knowledge.

In summary, an information-based investigation of fault finding reveals that the experience of complexity in problem solving is factored on a lack of problem solving information. The response of the engineers in overcoming this deficiency of information was, in large part, learning by doing - a strategy which was argued to be too slow and uncertain to guarantee the certainty the organisation expects of its engineers. The analysis further found that attempts to access this information from other engineers, both inside and outside the organisation, was constrained by the difficulty of defining what information they required, particularly that related to experientially based tacit knowledge. Their lack of contact with other experienced engineers highlighted a significant deficiency in their resources to deal with equipment faults. The next section investigates the

constraints in acquiring problem solving information which is external to the organisation by analysing the "information transaction".

6.4 BARRIERS TO ACQUIRING INFORMATION: AN ANALYSIS OF THE INFORMATION TRANSACTION

Macdonald makes the simple point that the existence of information at any location is explained by one of two reasons - the information was either transferred to this point or it was created there (Macdonald et. al., 1992, p. 79). So far, this case study account demonstrates instances of both scenarios: a full set of equipment manuals and a chief engineer with the necessary formal qualifications are examples of information having been transferred to the radio station embodied within documentary sources and human beings; the later scenario is depicted in the "learning by doing" of experiential knowledge development, sometimes a slow and uncertain process, which Macdonald describes as akin to "reinventing the wheel". Information which is external to the organisation is given special status by Macdonald in the resolution of intractable problems because existing stocks of information within the organisation have been found to be insufficient to contend with the problem. The barriers in acquiring information external to the organisation, namely overseas equipment suppliers, is of interest here.

The analysis focuses on the unusual economic characteristics Macdonald ascribes to information and the consequent need for information transactions when information is transferred. Macdonald (1998a, pp. 15-17) contends that information transactions are needed to ensure both the supplier and seeker of information establish an understanding of the costs and compensation before information transfer can take place. Implicit in the information transaction therefore, is the reckoning of costs the information seeker must pay and the likely compensation the supplier will receive. Macdonald contends that the

skill individuals and organisations develop in coping with these characteristics in facilitating these transactions of information have implications for the ways in which they learn.

An analysis of the information transactions in the case study reveals that factors peculiar to the organisation and the broader institutional setting in which the organisation operates are influential in determining the access these engineers have to problem solving information. While emphasis has naturally been given to the engineers, the seekers of problem solving information, attention is now also directed to the other party Macdonald identifies, the supplier of such information. Within the context of this study, equipment manufacturers are identified as an obvious and important source of information, their identity clearly apparent on equipment badges and in equipment manuals. The investigation looks firstly to the broader difficulties the radio station has in procuring tangible goods and cites this as an indicator of a more intrinsic problem in gaining access to intangible problem solving information.

At the time of the research, the radio station was required to channel all purchases through a central purchasing authority of the government. Ostensibly, the organisation did not engage in any direct contact with the supplier beyond obtaining initial quotations. It was necessary for these commercial transactions to be conducted across the legal jurisdictions of both the purchaser and the supplier. Extra safeguards were required to ensure reciprocal obligations were met. For example, the central purchasing authority required all original documentation to be exchanged using the post which incurred significant delays. Additionally, suppliers usually required payment to be made before goods were despatched. Consequently, delays of 5-6 weeks or more between initial ordering and final delivery were common. This has had the effect of embarrassing the chief engineer when he made contact with these suppliers.

> "I hate calling up overseas suppliers to ask for prices when I can't promise them they will be paid quickly".

The protracted nature of these transactions often requires the engineers to inquire with the supplier and the purchasing authority about the status of the order. When communication with the supplier does occur, it is dominated by the need to establish whether documentation or payments have been received and, if the goods have been despatched, their whereabouts in transit. This situation has prompted the chief engineer to channel what orders he can through a local business even though the main area of expertise of this establishment is in telecommunications. This relationship is more friendly and conducive to the purchase of goods as the local supplier is willing to bear some of the risk by using his established line of credit with his suppliers, as well as extending credit to the central purchasing authority.

If one compares this experience of the chief engineer with his colleague at the media unit of the local university, a number of contrasts are apparent. The media unit is a semi-autonomous entity within the university providing media services and training to academic staff and students. The unit is successfully run on a cost recovery basis. As a consequence, the unit has sufficient funds to cover their need for equipment, consumable items and repairs. A healthy commercial relationship has been established between the media unit and a company in Australia. The video officer who manages the unit only need fax or telephone a request for items such as tapes and the goods are despatched even before an official purchase order has been raised. The video officer claims he frequently communicates with his contacts in the Australian company and feels no reluctance to seek advice about problems he experiences with his equipment.[2]

2 The video officer has university qualifications in communication studies. As he is not an engineer, he may be also under less pressure to appear that he understands the intricacies of video tape recorder principles than the chief engineer, who has such qualifications. This issue is taken up later in this chapter.

From an information perspective, the barriers to contact with overseas distributors experienced by the chief engineer represent lost opportunities for more productive information sharing relationships. While the reluctance and embarrassment of the chief engineer is one factor working against the establishment of information sharing relationships, it is also possible to infer from the example of the university media unit that equipment suppliers will be reluctant to become too entangled in these associations if adequate compensation for their trouble is not expected. While common interest is one ingredient necessary for information transfer to occur, questions of compensation and issues of trust emerge as being equally important and essential to the transfer of information from the supplier.

Using the distinctions that Macdonald employs between formal and informal networks, it can be seen that the engineers are likely to have difficulty in compensating the supplier for information sought under either scenario. The difficulties of conducting commercial transactions over distances makes one wonder whether the monetary compensation for supplying goods are worth the complexities of these business relationships. If this is the case for formal transactions in tangible goods, one asks what inducements are there for equipment suppliers to supply information? If commercial transactions with the radio station are burdensome, perceptions of future commercial benefit from supplying information are arguably meagre.

Looking at the situation in which information transfer occurs on the basis of payment in kind, the prospects for productive information sharing relationships being formed are similarly poor. There is reason to believe that the engineers are unlikely to be considered a rich source of information to the supplier, at least as far as knowledge of the products in question is concerned, thereby raising doubts about the value of payment in kind. The following example suggests that perceptions of the abilities of these engineers amongst suppliers is poor. For example, on one occasion, the engineers were accused of contributing to the failure of a high voltage switch used to direct each of the transmitters

to the transmitting mast. The damage was caused by excessive arcing which would have been clearly visible and audible to anyone in the transmitter building. Despite this, the engineers were accused of repeatedly switching the transmitter on, suggesting they were unable to associate the damage to the switch with the loud and visible arcing. Indeed, the engineers claim that the damage occurred in their absence and point to the automated system which controls the switch. They argue that the cause of the problem was clearly attributable to the lack of foresight of the designer in not predicting what was ultimately found to be the problem - poor contact alignment in the switch due to a loose nut.[3] Nonetheless, the engineers were assumed to be the cause based on poor perceptions of their abilities. This suggest that it would be difficult for relationships of trust to be built in such circumstances and hence difficult for information sharing relationships to be established and developed. The prospect of problem solving information being transferred is therefore slim.

So, distance is not the only manifestation of "isolation" these engineers must cope with and the above problem cannot be ameliorated by merely providing a telephone line. The transfer of information appears to be dependent on something which stands apart from the actual channel, be it a telephone, fax, e-mail or face-to-face conversation. From an information perspective, this element is revealed by the information transaction, in which the costs to both the supplier and receiver need to be accounted for. While it may be obvious to state that without a telephone line there can be no information transfer, it can be equally claimed that the absence of elements such as common interest or trust, whether underlined by commercial confidence or personal relationships, will also constrain the transfer of information to these engineers.

[3] Such attitudes amongst suppliers may be a factor related to the expense of undertaking warranty repairs. As warranty repairs in the Pacific region are likely to have a marked impact on profit margins, the opportunity to cast blame on the engineer can be viewed as a way of reducing the company's obligations to undertake warranty work. Alternatively, interviews with engineers in other broadcasting organisations in the region suggest others have similar experiences with equipment suppliers. For example, the former technical coordinator of the regional broadcasting body, the Pacific Island Broadcasting Association (PIBA), revealed that he had difficulty in acquiring the most basic of information from companies. His requests for quotations were often left unanswered which is even the more unusual, as he had funds to back these requests up with purchases. His comment to me was: "...I have money to spend but I have to beg them to send me prices..."

As equipment suppliers are identified as a primary source of knowledge for these engineers, it follows that difficulties in establishing commercial transactions with these suppliers have implications for the establishment of relationships of trust conducive to the transfer of "difficult-to-get" tacit information. Therefore, it can be asserted that the institutional relationships linking the organisation to the purchasing authority and, in turn, to the overseas equipment supplier, work against the establishment of viable networks of communication with sources of potentially rich problem solving information. While the bureaucratic procedures have arguably been instituted to counter the problems of smallness and isolation, on closer analysis they are found to compound the effect of these constraints by presenting more intrinsic barriers to the transfer of information. Also implicated are overseas equipment suppliers, whose perceptions, whether based on commercial acumen or ignorance, are also influential in determining the access these engineers have to problem solving information. Clearly, there are factors quite apart from the competency of individuals which are responsible for shaping the information sharing relationships the engineers share with overseas equipment suppliers.

Another aspect to the organisation's influence over acquiring problem solving information is apparent when one looks more closely at the reluctance of the engineers to contact the transmitter manufacturers when experiencing faults with the back-up transmitter (Transmitter 2) and the parliamentary broadcast transmitter (Transmitter 3). On first appearances, these occasions could be viewed as further examples of the difficulties in establishing viable commercial relationships with equipment suppliers. As the transmitter had originally been purchased as part of an aid package, it could be argued that there was little commercial impetus for the manufacturer to assist the recipients of this aid. However, subsequent interviews with the transmitter's distributor in Australia cast a significantly different light on the matter and led me to consider other factors constraining information transfer besides commercial benefit to the supplier. The distributor readily admitted that they were motivated by commercial concerns, yet stated that the cost of

providing the 24 hour technical help service had been accounted for in the purchase price of the transmitter. In terms of providing compensation to the supplier of information, this cost had been paid in full in advance by the aid donor.

In analysing other possible reasons why the opportunity to consult the technical service was not taken, issues of material and non-material costs to the organisation and the engineers were considered. Slamecka (1982, p. 66) raises the issue of shyness as one possible reason for the poor transfer of problem solving information to developing countries, but this explanation does not relate well to the chief engineer. In this case, the chief engineer is quite proficient in English and I have noticed that he is able to develop good rapport with people, both local and expatriates. The high cost of telephone calls also figured prominently in consideration. With international call costs for voice telephony at approximately USD $1.50 per minute, the burden of payment is certainly more for those with less to spend and as a consequence, communication with the outside world is constrained by a need to ensure communication costs are kept within budget. Still, even the high costs of telephone calls does not fully explain why, in times of dire need, (such as the example of the faulty parliamentary broadcast transmitter), contact with the transmitter manufacturer was not sought. The following analysis suggests that more intrinsic matters related to the non-material costs in acquiring problem solving information are responsible. The following discussion develops an understanding that central to the engineers' reluctance in seeking assistance from the manufacturer is the issue of maintaining personal standing among colleagues in the organisation, as well as the general community. In order to appreciate this more fully, it is necessary to try and view the situation as best as we can from the engineers' perspective.

The failure of a radio broadcast transmitter is a very public event and the small size of the community doesn't allow the kind of anonymity one might enjoy living in a larger community. For example, the chief engineer told me that he is often approached in the street by individuals seeking explanations of happenings at the radio station, including

equipment faults. As argued in chapter 5, the technical complexities are compounded by the social demands made of the organisation and in turn, of its engineers. Coupled to this appears to be a poor appreciation of the complexities of engineering. The manager commented to me:

> "I don't understand the technical side as well as the...[former manager]...so I rely on the...[chief engineer]...to tell me what's going on. I sometimes feel he is hiding things from me and I don't know why".

Staff training and development is largely conceived in terms of the theoretical knowledge gained from education and training. Expectations are such, that the attainment of formal qualification confers one with an ability to solve problems, even if one has just arrived home from overseas tuition. This is most visibly seen in the way the chief engineer was quickly promoted to senior responsibilities without attaining sufficient practical grounding. He is vulnerable to criticism during difficult equipment faults, as revealed in the comments of one announcer who complained about the length of time taken to repair an item of studio equipment.

> "He walks around here all puffed up but the cartridge machine is...[broken]...for two weeks".

The organisation appears to be slow in responding to the chief engineer's requests for more resources, such as the need for more experienced colleagues. He has been lobbying for some years to have the vacant position of Chief Technical Officer filled. As a recommendation running counter to the policy of reducing staff, his requests of many years have been "falling on deaf ears". His request, however, was finally granted after two occasions in which the radio station was off-air for extended periods of time because he was unable to get to the studio. One occasion was when he was sick (detailed in Chapter 5) and the other occasion was when he was in transit to Savai'i on the inter-

island ferry. After a two hour journey, he was informed on his arrival that the station was off-air and directed to return immediately! The chief engineer feels considerable frustration at the difficulties he has in explaining and justifying his requests for more resources. His comment to me was:

> "I feel like there is no trust there".

On the other hand, there may be reason for some mistrust to develop. The manager admits to being surprised when, after being given assurances by the chief engineer that the problem with the parliamentary transmitter (Transmitter 3) was in-hand, she saw the frenetic activity at the transmitter building on leaving the studio later that night. It is likely that the communication barriers that the manager refers to between herself and the chief engineer are derived from a fear over loss of status, if he is seen not to be able to single handedly solve the problem.

The need to maintain one's status is not only for the benefit of the individual but also for the sake of the family, who usually invest considerable resources in supporting the education of family members overseas. Families celebrate the educational achievements of their kin where qualifications are seen as the basis for added standing in the community. This was made obvious to me during attendance at a church service. A recently returned student was officially welcomed home by the pastor and much back slapping and hand shaking occurred at the completion of the service. Students returning without their qualifications are not given similar recognition, even though their experiences have been just as difficult, if not more. I was surprised to learn over lunch with the pastor that these people do not attract much sympathy as there is a feeling that they have let their families down.

> "We all know it is tough to be lonely and be away from family and friends but we all have to live with that....There is a feeling there that they did not do enough to put those difficulties behind them and get on with the job".

While studies such as Orr's suggests that advice seeking is not only normal but necessary for technicians, within the context of this community, needing outside assistance is likely to be perceived as an admission of being unable to solve the problem single handedly which may reflect poorly not only on one's self but their families as well. In this context, contacting the manufacturer for advice, even late at night, is not an attractive option for the chief engineer. As the high cost of international telephone calls ensures that the itemised telephone bills are scrutinised closely by the accounts staff and the manager, any communication the chief engineer has with the manufacturer is apparent when enquires are made as to the reasons such calls were made. While the status of the technical help service as a formal or informal arrangement is not wholly clear, the lack of organisational scrutiny Macdonald describes as being required for informal networks to flourish would clearly be of benefit to the chief engineer here. This example suggests that the behaviour of individuals is once again being shaped by the contingent circumstances of the organisation and the community rather than by a lack of individual proficiency.

The engineers are therefore constrained in three important ways in their ability to "pay" for problem solving information. Firstly, the limited financial means of the station reduces the commercial impetus pressing the equipment suppliers to assist by providing problem solving information. Secondly, the exchange of information through payment in kind is judged to be unlikely. Whether correct or not, perceptions of the limited experience of the engineers by equipment suppliers suggests they have little information of value to the equipment supplier to trade. And thirdly, the need to conduct this communication under scrutiny from the broader organisation means that the engineers are required to trade some of their status as competent engineers in order to access the information source provided by the manufacturer - a price which is arguably too high for

them to pay personally or on behalf of their families. The informal information networks Macdonald's identifies as being so important in transferring "difficult-to-get" information are not possible for these engineers as any international communication they engage in is, by definition, formal communication which is open to the scrutiny of the organisation.

In summary, an information based analysis of the case study participants identifies the organisation as influential in determining access to problem solving information. The limited involvement of the engineers in interpersonal communication networks with other broadcast engineers is an area of significant concern for the case study participants in gaining access to the knowledge of more experienced practitioners. While the high cost of telephone calls is one obvious factor constraining the formation of such networks, factors more intrinsic to the nature of the organisation are also significant. The difficulties the organisation has in maintaining viable commercial relationships over distance are argued to provide a poor basis on which to build relationships of trust, commercial or personal, necessary for the transfer of information. The costs in seeking assistance from outside the organisation in terms of personal standing with organisational colleagues are deterrents to the formation of relationships with outside agents despite considerable evidence to suggest that such links are necessary for these engineers, particularly in the early stages of their careers. The processes by which these individuals learn is found to be markedly influenced by specific attributes of the organisation and its relationship to the broader social setting.

6.5 THE ORGANISATION AND CAPABILITY DEVELOPMENT

Responding to the research question at the centre of this chapter's investigation, the analysis effectively maps a number of ways in which the organisation facilitates and constrains problem solving. This was done by firstly reflecting on the experience of the

engineers in fault finding and noting that much of the complexity of fault finding can be associated with coping with deficiencies in problem solving information. From Macdonald's information perspective, education, training, experience and communication together, provide the means by which people develop a readiness not only to receive and use information, but also to demand further information in their quest for more knowledge. Technological capability development is portrayed here as a on-going and dynamic information-based process where one's engagement with the faulty machine, the equipment manual and knowledgeable others contributes to an increasing ability to better define one's ignorance of the machine.

While the individual has an important role to play in developing their readiness to demand and use information, the analysis suggests that the organisation is instrumental in providing the engineers with the resources essential to the resolution of these problems. While the radio station is seen as doing this when it provides education and training as well as equipment manuals, tools and the like, an analysis from an information perspective suggests more subtle factors at play. The organisation is implicated in hindering the transfer of problem solving information by constraining participation in information networks. The examples cited in the preceding analysis demonstrate how contingent social circumstances can influence the behaviour of the engineers. In contrast to the idea that the radio station has only an "arms-length" involvement in the development of technological capability in terms of education, training and the provision of other resources, an information perspective argues that the organisation is an actor which is intimately and continuously engaged in this capability development process through problem solving. These constraints are not just inefficiencies which may on occasions disrupt the development of new knowledge, but represent a chronic problem in which these engineers are denied access to the necessary expertise of others on which the development of their own abilities depend.

From this perspective one can also examine the radio station's history to help understand capability development today. The difficulty the radio station had in retaining technical staff during the 1980s[4] can be seen as having a marked impact today by the fact that there are no knowledgeable "elders" for the engineers to turn to. The difficulties the chief engineer had in convincing his superiors of the need for another person of experience reflects, in another way, how the broader institutional setting is responsible for constraining problem solving, and by implication, the capability development of these engineers.

As problem solving is considered an essential input to the development of technological capability, it follows that the organisation's role in constraining and facilitating access to problem solving information marks the organisation as an important actor in the creation of technological capability. While there is an obvious and essential requirement for "able" individuals and the provision of appropriate levels of formal tuition, the organisation is found to be an influential determinate in the process of technological capability development through problem solving. This chapter therefore asserts that the organisation is critically important to the resolution of problems and hence, capability development.

6.6 CONCLUSION

The investigation of this chapter argues that technological capability is made up of two parts - the individual's ability and an organisational ability to facilitate the efforts of these individuals. This assertion is drawn from the finding that the complexity of fault finding these engineers experience is derived from their difficulties in eliciting problem solving information either through learning by doing or from other information sources,

[4]See Preface

particularly those outside the organisation. Through an analysis of the "information transaction", as described by Macdonald, acquiring problem solving information was found to be constrained by a number of difficulties which contributed to the experience of complexity. Firstly, it was difficult for the engineers to define with any certainty, the kind of information they wished to receive. Their lack of participation in information networks with other experienced practitioners, notably equipment suppliers, was identified as a serious problem. Information networks were argued as the primary means by which the information seeker's difficulty in expressing demand is overcome. Equipment suppliers and the organisation were implicated in constraining the ability of these engineers to participate in productive information sharing relationships. Hence, the processes by which these individuals learn are found to be markedly influenced by specific attributes of the organisation and its relationship to the broader institutional setting. The thesis therefore argues that, for the case study engineers, technological capability is largely created within the organisation.

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Chapter 7

Foreign Interests, Local Society and the Organisation

7.1 INTRODUCTION

In view of the instrumental role the organisation plays in the development of technological capability, this chapter seeks to determine what factors influence the organisation to be what it is. In effect, the social dimension of problem solving, identified in Chapter 5 as organisational demand, is further investigated in order to support inquiry into the principal research question "how do the engineers solve problems within the context of smallness, isolation and cultural resistance to change?".

The chapter is concerned with defining how the identified Pacific themes of "smallness", "isolation" and "resistance to change" contribute to the characteristics of this organisation. The analysis of Pacific Island development literature essentially marks out three portrayals of the quintessential engineer by the organisation to which he or she belongs: "Cadres of Modernisation", "Pawns of a Global Hegemony" and "Part of the Pacific Way". Initial investigation in this chapter is accordingly concerned with responding to research question 4, "which scenario is most appropriate in understanding the organisation and engineers under scrutiny in this study?". The analysis looks to both events within the radio station and the broader political arena to determine responses to this question. The second part of the chapter explores the last research question formulated, question 5, "what implications does this finding have for an understanding of technological capability for Pacific Island engineers?". The chapter argues that the

organisation is a creation of local political and historical circumstances. Within this context, perceptions of resistance to change are at best a partial description of the social processes which contribute to technology-based change. The case study engineers emerge as being at the cusp of two cultures, that of the community in which they live and that of an engineering culture. The thesis further argues that they are required to be competent members of both. The chapter concludes with a number of recommendations which respond to an identified need for these engineers to be granted more authority to command resources of the latter in order to serve the former.

7.2 WHAT SOCIAL PURPOSE FOR THE ORGANISATION AND ITS ENGINEERS?

The review of literature undertaken in Chapter 3 reveals three broad areas of thought regarding the relationships between imported technology, the organisation, and the local community. The underlying principle of the modernisation thesis, a dominant area of thought, is one in which social change is factored on the adoption of western models. Alternatively, commentators such as Hill (1988; 1994) and Molnar (1994) argue that such initiatives pose a serious threat to indigenous culture, pointing to the likelihood of exploitative dependent relationships between foreign interests and Pacific Island communities. The third view, derived from the work of Pacific academics such as Veramu (1998a; 1998b), Halapu'a (Field, 1998; Petelo, 1997) and Wendt (Hereniko, 1997), and European historians such as Thomas (1991) and Hempenstall (1978), is to perceive the process of technological and economic change more in terms of a "re-contextualisation" process where it is acknowledged that the adoption of foreign technological artefacts does indeed induce change but the process is, or should be, one which is determined by the authority of indigenous institutions.

The three approaches each imply a different social role for the both the organisation and the engineer. The first suggests that engineers, through their engagement with western machinery and education, are part of an emerging cadre who will accordingly promote modernisation strategies in the locally based organisation. The second view portrays the engineer as the pawn of global capitalist enterprises, leading a double life divided between the technical world of their occupations and that of the local culture of family and the village. The third approach sees them as key players in a change process in which modern western artefacts are oriented to uses that are in accord with local values and one in which local needs give rise to new areas of competencies.

The task of determining which approach best reflects the situation of the radio station and its engineers is complicated by evidence to support all three portrayals. For example, the radio station can be seen as playing an active role in promoting modernisation in its role as an advertising medium. The radio station broadcasts advertisements during four weekday time slots - morning, lunch, late afternoon and evening which are usually hosted by announcers most popular with the public. Advertising of goods manufactured locally (mainly food products) and imported from overseas is a vehicle by which mass consumption and the cash economy is encouraged. The radio station also plays a part in contributing to the cash economy by paying its staff weekly wages.

Other indications of the radio station's role in promoting western-based values is seen in areas identified by Hill (1988; 1994) and Molnar (1994). There is clear evidence of the ordering effects of western technology over local institutions, as argued by Hill (1988, pp. 85-86), in that there exists a direct relationship between the organisational structure of the radio station and the physical artefacts of radio broadcasting technology. In as much as the radio station needs tape recorders, audio consoles, transmitters and the like to fulfil the technical requirements of distributing information and entertainment to the community, these same objects can also be seen as demanding complementary human resources in order to perform this function: that is, people with the capacity to create

programme content, specialists who can operate and maintain equipment and administrators who ensure people get paid, items are purchased and so forth. The knowledge required to fulfil these demands reflects the importance attached to the individuals holding such positions within the organisational structure and wage levels of the respective positions confer levels of authority to the incumbents. There is also evidence of the potential for friction between authority mandated by the organisation and authority conferred through the traditional means of local society. One member of the technical section holds a title of traditional rank while his immediate supervisor does not.[1]

The radio station also seems to fit Molnar's (1994, p. 106) characterisation of the '.."big" national media...', something she claims as common in the Pacific where programming choices are dominated by local political power and foreign interests. The notion of what constitutes local power as far as the radio station is concerned is quite clear; the manager's immediate superior is the Prime Minister. Certainly, the wide spread popularity of the radio station has led some critics to argue that it has become a tool to promote the interests of government to the detriment of other local interests. For example, the radio station was criticised for its coverage of demonstrations protesting at the introduction of a Value Added Tax (VAT) in 1993 (Hildebrand, 1998a, pp. 10-13; Peteru, 1997, pp. 30-31). As this taxation policy has been actively promoted by bodies such as the World Bank and the Asian Development Bank (e.g. See Foster, 1996, p. 24; Hildebrand, 1998b, p. 7) this is an example of foreign institutions dominating the policy

[1]Alailima (1988, p. 335) explains Samoan traditional rank in the following way.

> In traditional Samoan custom, everyone belongs to an extended family or several such families, being eligible to activate membership in as many as appear in his maternal or paternal family tree. Each of these groups or relatives carries a title and usually bestows it on some member of every generation. Henceforth, he...[or she]...is called by that title, his...[or her]...own name being appended only to distinguish him...[or her]...from previous title holders. Every title carries with it a role (titular chief or orator chief) and a rank in some council (*fono*).....

Freeman (1983, p. 130) adds:

> It is also said by chiefs that the relationship between themselves and untitled individuals is set apart, and that a chief (whether titular or talking) is entitled to the respectful obedience of all those over whom he has authority....Central to Samoan society, then, are the closely related principles of the right of those of superordinate rank to exercise authority over those who are below them in the social order, and of the obligation of those in positions of subordination to obey the dictates they receive from above.

setting agenda of local government and by implication, the radio station. Molnar's (1994, pp. 106-107) model of more appropriate (simpler) technologies and (smaller) organisations designed to give local interests access to media technologies is evident here as well. The local private FM gives air time for opposition groups to broadcast their opinions (Peteru, 1997, p. 31).

Case study descriptions also give credence to Molnar's (1994, p. 117) concern over the use of radio broadcasting to facilitate the entry of other expressions of western culture, namely music and short wave news broadcasts. Both western and local music is broadcast. A regime has been established where twenty minute brackets are devoted to playing western and local music alternately during the day. Interestingly, music with words in the vernacular but sung to a popular melody of western origin is generally played in the local music bracket. One staff member is allotted the task of translating foreign news broadcasts into the vernacular for broadcast at lunch time and evening every week day and Saturday.

On first appearance, one could surmise that the radio station has actively promoted the introduction of western cultural forms, such as organisations, music and news, through the use of broadcasting technology. In some instances, it can also be inferred that some aspects of this process of technology-induced change have had a negative impact on the community, such as the promotion of mass consumption (and its consequent ecological affects - see Siwatibau, 1994) and the conflict between organisational-and traditionally-conferred authority. However, difficulties arise with both the modernisation and dependency views of development when events within the radio station and in the arena of local politics are scrutinised. These two areas of social activity reveal a more complex set of relations at play than just those which exist between foreign interests and a local elite who may benefit from such relationships.

Beginning with the radio station, it can be seen that explicit measures have been taken to counteract the intrusions from foreign cultural forms. The allocation of set brackets for English and local music is designed to ensure western music doesn't dominate the programming of (the mainly younger) announcers and recognises the sensibilities of listeners who prefer to hear locally produced music. Indeed, much of this local music is drawn from the radio station's own recordings of artists, some of whom have moved on to become popular musicians locally and abroad. The significance of compositions sung in the vernacular to a popular western melody, depends on one's perspective. While the radio station's programme director, who has responsibility for vetting all music played on the air, views this as a case of free riding, he has difficulty in dissuading the announcers playing such music as it has proved very popular with the listeners. One could cite the unauthorised copying of the melody as being evidence of the intrusion of western culture. However, the other view, which sees these songs as being most appropriately played during the local music bracket, is more disposed to judging this as an instance where some discrimination has been employed in rejecting the words whilst accepting the melody.

The importance which is attached to the live broadcasts of events which are of cultural, and general (sporting) interest suggest that the radio station endeavours to meet the demands of the listening public. Often the radio station receives customary gifts of food and fine mats after such events. During my previous tenure as a technical adviser, I witnessed many instances in which the radio station was treated as a distinct social unit within the local community. The giving of gifts and food for occasions involving staff members such as weddings or funerals was reciprocated in the traditional way. This meant that the family of staff members would present gift of foods and finely woven mats in return in appreciation of the gifts given by radio station staff. Senior members of staff were required to assemble and officially receive these gifts. One staff member, an orator chief, would accept these gifts by way of a formal speech. The orator chief then supervised the distribution of these items to staff members.

Relationships between staff members are similarly governed by the norms governing social exchange. For example, showing respect and deference to more senior members of the family and community, has been extended to the organisation. My observations of the behaviour of junior members demonstrated a complete deference to more senior members of staff where complaints or negative comments were reserved to the informal interactions in the tea room or over a cigarette outside. Exchanges between staff of similar authority, whether conferred through the organisation or by traditional means, is characterised by respect and mutual deference.

So, it is from this perspective of the radio station being a relevant social unit within the context of the community which is responsive to the local demands of both listeners and politicians, that an understanding of the apparent "clash" between organisation-conferred authority, mandated by western technology, and community-conferred authority, mandated by local custom, can be advanced. The twin ideals of respect for those of higher authority and dedication to one's family, so important to the maintenance of local culture, are extended to the organisation. Organisational authority seems sufficient grounds for the accord of respect because of the function the radio station performs within the broader community, subsumed under the authority of those influential in local culture. Hence, the prescriptive power attributed to foreign technology by Hill (1988; 1994) in extinguishing local culture is overstated within the context of this study.

If one adopts the broader perspective encompassing local politics, it becomes apparent that the dichotomy that Molnar (1994) employs separating local culture from local political power and allying the latter with foreign interests, is difficult to sustain. Examining what constitutes this notion of local power, it is evident that the political structure is linked with two other structures of authority: traditional authority and the church. The biographer Alailima (1988), by virtue of her husband's close association with figures instrumental to the formative processes leading up to the independence of

Samoa from New Zealand in the 1950s and early 1960s, has incorporated a significant amount of information into her accounts about the underlying goals of these key individuals. She reveals determined efforts were made to ensure traditional power was embodied into the political institutions of the new state (Alailima, 1988, p. 263). So, while political power is ostensibly represented by a Westminster system of government it was modified to limit suffrage and eligibility to stand for parliament to people holding traditional titles.[2] Authority in one sphere is therefore often dependent on authority in another (Alailima, 1988, p. 282). A recent example of this is seen in the actions of one village council who banished its local member of parliament from his village with the consequence of his eligibility to be a member of parliament being revoked (PACNEWS, 1997). The legality of such actions are assured through the Village Fono Act which gives village councils legal jurisdiction over local village members.

The position of Head of State provides another example of this. It is ostensibly a ceremonial position with the occupant holding executive power over government. The Head of State is also a paramount chief and is the principal figure of the *Tumua* and *Pule*, a group of the highest ranking orator chiefs who are traditionally regarded as the principal determinate of traditional power (Field, 1991, p. 22). The Head of State is able to command considerable authority. For example, his decision to banish a senior orator chief of his clan was met with complete obeisance by the local media, public and private (Polu, 1997a, pp. 13-14). In contrast, the legitimacy of government's decisions are constantly under scrutiny by the private media (PACNEWS, 1999; Peteru, 1998a, p. 26). One can argue that both authoritative structures, political and traditional, are representative of broad community interests as power in both structures is conferred through agreement amongst family clans. Interestingly, traditional authority appears to enjoy greatest legitimacy in the hearts and minds of many people, including the educated.

[2] Suffrage was extended to all citizens in 1993. Eligibility to stand for parliament remains limited to chiefly title holders.

The church also has an established hierarchy and Alailima (1988, p. 282) describes it as an influential force in local politics too (See also, Peteru, 1998b, p. 39). Christianity, while also ostensibly a western cultural form, is regarded by some as being well adapted to local customs. This is partly explained by the degree of similarity between the Old Testament Jehovah and the Samoan pre-Christian belief in the god *Tagaloa* (Freeman, 1983, pp. 180-183). As Wendt (1987, p. 125) describes in one of his novels, the God of Christianity is largely seen as the originator of local customary practice, commonly referred to as the *Fa'a Samoa.* Alailima (1988, p. 282) observes that some people, in being active in the church hierarchy, have consequently furthered their interests in the traditional and political spheres.

Look to the controversy over the imposition of a VAT tax, and it can be seen that these three authoritative structures are engaged in a struggle in which allegiances are spread across political, traditional and religious associations (Hildebrand, 1998a, pp. 10-13; Peteru, 1997, pp. 30-31, Polu, 1997c, p. 27). These influences are seen to combine in an apparently ad hoc way to determine the course of a debate which is distinguished by it unique local character. Media accounts of the VAT protests reveal traditional power, the *Tumua* and *Pule*, were those who provided the authority for such marches. The Head of State made direct submissions to government of behalf of the *Tumua* and *Pule*, who requested his intervention. The presence of Catholic nuns and priests at the demonstrations drew comment from the Deputy Prime Minister who accused these church representatives of supporting cigarette smoking and alcohol consumption (as these two commodities were high on the list of items opponents demanded to have the tax removed from) (Polu, 1997c, p. 27). Coinciding with this agitation over the VAT was concern over government accountability for expenditure of public funds (Hildebrand, 1998a, pp. 11-13). This question along with the related controversy over the sacking of a government auditor represent instances which work against the goal of greater transparency in public administration, a desired goal of foreign lending institutions. Further complicating this issue, is the influence of individuals who have formed non-

political organisations designed to promote greater public awareness and action over these issues account. Accusations from government that the leaders are politically motivated because of family connections with opposition politicians (Peteru, 1997, p. 31) left one activist to ponder the reasons for his involvement as it cuts across a number of familial associations.

> I am the nephew of the leader of the opposition, one of our [family] members is closely related to a government minister, I am also the cousin of the minister of health. For years I had been partying and going on but when the...auditor...thing came along, I said no, no, no more partying for a while. It's time for a change (Hildebrand, 1998a, p. 13).

The particular drama which is played out in this instance is not only influenced by issues of both foreign and local origin but is further coloured by the peculiarities of indivudal participants.

At this point, a difficulty in Molnar's (1994) analysis emerges as it becomes extremely difficult to determine where local culture ends and local politics start. Further, it is difficult to sustain any notion that there is a conspiracy, or a uniform alignment of interests, between local politics and foreign interests determined to undermine local culture. The evidence suggests considerable reason not to over-determine the characteristics of international relationships between cultures in preference to what is occurring within local culture. The associations Molnar draws are too simplistic. In terms of the circumstances this study describes, Molnar fails to come to grips with the relationships which exist between local culture, local politics and the church. In assigning a role for local culture which is submissive to the incursions of foreign culture, Molnar understates the influence of local culture over local politics and diminishes the culture she is purporting to promote.

Therefore, Molnar's enthusiasm for small and appropriate broadcasting organisations to counter the domination of the big government media is likely to be an undertaking more onerous than her commentary gives credit. It is difficult to see how these organisations, characterised by their size and the kinds of equipment they employ, can exist in isolation from the broader processes of society. For example, discussions held with the manager of the rival FM station suggest one strong reason to pause for thought. While the radio station is one of the few media organisations through which opposition politicians are able to express their views, there is also a need to weigh carefully the costs and benefits of doing so. The main stay of the FM operations is advertising and as public radio also carries advertising, the lower advertising rates charged by public radio effectively set the rates the FM station is able to charge. The manager of the FM station wishes to see higher advertising rates and the only way this can be done is by government allowing the increase of advertising rates on the public radio. So, the viability of the FM station is still very much connected to the broader political process.

In summary, the discussion leads to the assertion that the radio station is far from being an analogue of radio stations one might find in Australia, New Zealand or the United States. While organisational structures reflect the broader imperatives of broadcasting technological forms, these have been adapted in various ways to meld in with the broader community. The tenacity of local culture in constraining the pace and direction of change is a force in contesting the claims made by these foreign cultural forms. No doubt, broadcasting represents a powerful tool to local political interests but these issues are currently being contested by those who, along with Molnar, see a more "democratic" use of these media forms (e.g. See Polu, 1997b, pp. 3-4). Hence, in terms of coming to a deeper understanding of the forces which are important in directing the activities of the radio station, it is clearly insufficient to adopt Hill's view of technology's prescriptive power over culture or the simplistic associations and divisions advanced by Molnar. The analysis suggests that there is a need to perceive the integration of broadcast technology within the circumstances of individual communities which in turn allows one to see the

local imperatives that direct the efforts of individuals who may be somewhat out of step to the dictates of foreign interests. The chapter shows therefore, that the broadcasting organisation is primarily a creation of the uncertain convolution of local historical, political and contingent circumstances.

Within this milieu stand the engineers of this study. It was argued earlier that the organisation is influential in determining the priorities to which the engineers work. By asserting that the organisation is largely a creation of local circumstances, the portrayal of the engineers which emerges is one in which they are engaged in the important task of orienting foreign technologies under the direction of local authority. Such a process seems to be reflected in the assessments of the Programme Director of the radio station. He argues that the reforms advanced by foreign lending institutions represent both good and bad news for his country. For example, he sees benefits in the push for greater public service accountability. On the other hand, the dictates which are more difficult to implement because of community opposition require modification to make the initiatives more acceptable. He sees the role of government and its various instrumentalities to adapt such policies in a way which "...conform to the general spirit of reforms but softens the impact to people...". In terms of the argument that western technology represents a threat to local culture, he gave short shrift to the idea by suggesting that it was an excuse for laziness.

It is clear that the imperatives which drive the radio station are political but these imperatives are much too diverse to be described by the alignment of interests with foreign aid and lending institutions. This is reflected to some extent in the diversity of information needs the radio station attempts to serve. The support base for local politicians is tied to traditional authority which ultimately has the power to deny individuals endorsement in the political arena. So, out of the three portrayals formulated from the literature analysis - "Cadres of Modernisation", "Pawns of a Global Hegemony" or "Part of the Pacific Way" - the chapter argues that these engineers are primarily

oriented to serving local interests rather than foreign interests, thereby associating them best with being "Part of the Pacific Way".

7.3 THE LOCALLY CONSTITUTED NATURE OF TECHNOLOGICAL CAPABILITY

In rejecting explanations of technology diffusion in the Pacific region informed by the optimism of modernisation theorists or the pessimism of dependency theorists, attention is now directed to determining a response to research question 5. This question asks what implications an understanding of the engineers' subservient relationship to local culture has for their technological capability development.

By asserting local culture with an instrumental role in the process of technology diffusion, an organisation emerges which uses modern western technology but is primarily motivated by the need to serve local interests. Those employed by the organisation are thus similarly subject to the authority of local interests. This raises questions about the goals of economic efficiency in the studies by Enos (1991) and Bell and Pavitt (1993). The utility of economic efficiency as a measure of technological capability only makes sense in communities which celebrate these measures as indicators of progress. If a community essentially views its well-being in terms of indicators specific to their locality, the concept of "technological capability" should logically be measured within this construct if one is to develop any meaningful understanding of the relationships governing the adaptation of modern technology. In effect, Higgins' (1994) observation of "resistance to change", mentioned earlier, may indeed reflect a process of adaptation which is factored on the pursuit of unrecognised or unconventional goals.

A number of examples emerge from the case study descriptions which reveal a distinctly local character to capability development. One example is the high priority which is accorded to the broadcast of the Sunday night church service. The local significance of this programme is apparent in the chief engineer's efforts to ensure the church service is recorded and broadcast on time every Sunday evening. In effect, the reputation of the radio station for the ensuing week is very much dependent on the successful broadcast of this programme as conversation first thing Monday morning inevitably turns to the topic of the church service if problems occurred.

Demand for the live broadcast of Sunday night church services has, in the past, provided the foundation on which the engineers have built a considerable capacity to mount live outside broadcasts.[3] The notification of a church service in a district from which no live broadcast had been previously performed serves as an opportunity to research and test various methods of establishing the necessary radio frequency links between this locality and the radio station. A combination of the demand from the community and the mountainous terrain of the countryside has proved a powerful stimulus for problem solving and knowledge creation. While it could be claimed that this knowledge may not be objectively new in that the principles governing the propagation of radio frequency signals are well established, there is justification in stating that the application of these principles to the local circumstances is new. So, to the extent that this has never been done before, this problem solving process can be judged as an innovative activity in the sense of Rogers and Shoemaker's (1971, p. 19) statement, '...[i]f the idea seems new to an individual, it is an innovation...'. From the perspective of the engineers, the challenge and involvement in these activities can certainly be equated with the enjoyment and excitement of contributing to this growing capability.

[3] Live broadcasts have been discontinued for the benefit of the television station. As the television station is not able to stage live broadcasts, the church services are now recorded in the afternoon prior to the service. Such is the allure of television, the radio station has had to accommodate this apparent short coming of the television station as the public are keen to see the church service on television.

Another example of the local nature of the goals which shape perceptions of technological capability can be seen in qualitative judgements of what constitute adequate levels of technical quality, as opposed to quantitative measures which are reflected in signal to noise ratio (SNR) measurements. Minimum specified levels of this measurement for tape recorders are of the order of 55 dB below standard reference level. SNR measurements noted by me during tape recorder alignment were of the order of 35 dB - well below minimum specified levels. Notably, these levels of SNR did not elicit any comment from programme staff, or more generally, complaints from the general public. Without any significant demand, the only compulsion to maintain technical levels of 55 dB appears to be a zealous attachment to engineering standards. Within the context of aging equipment, in which maintaining these SNR levels becomes an increasingly difficult and tedious task, it is perhaps understandable why these standards are let slip over time. In terms of the tension between what is considered acceptable quality in an engineering sense and in a social sense, the goals to which the technological capability of these engineers are being directed is heavily influenced by the local perceptions of acceptable quality.[4]

Yet another demonstration of the locally determined goals of technological capability development is seen in the failure of the digital audio computer in the on-air studio - a device which is intended to take the place of conventional analogue tape recorder equipment. Used for recording and replaying music, jingles, advertisement, programmes and the like, the audio computer's function is similar to that of a conventional tape recorder except that items for replay can be programmed into playlists which can be manually triggered by the announcer or automatically by the computer at a specified time. I noticed that the digital audio computer had been out of service, and on asking the announcers, was told that it had been so for a number of months. In response to this situation, the announcers had reverted to older practices using the analogue tape recorders and had not placed pressure on the engineers to have the device fixed.

4 Using this reasoning, it is also understandable that equipment is kept in service well beyond the time the manufacturer feels the need to maintain an adequate inventory of spare parts, as was the case with some items of studio equipment during my earlier contact with the radio station (see Preface).

It can be argued therefore, that making comparisons between this organisations and those operating in regional centres such as Australia or New Zealand on the basis of the similarities of technology used, is likely to lead to incommensurate standards of goals and progress. This is because the social aims driving these respective organisations are likely to be different. Coming to a meaningful understanding of this process of technology adaptation therefore, may be difficult to attain. An illustration of this point is found in a related example where Wendt (Hereniko, 1997) comments on recent research interest in colonial literature from the Pacific. In referring to the Samoan *tatau* (tattoo), Wendt makes the provocative point to those undertaking research into Pacific Island colonial literature that investigations which look only to documentary sources miss out on seeing the "stories" contained within other important Pacific cultural symbols, such as patterns inscribed in the skins of those receiving the traditional rite of the *tatau*. The point being that understanding is inevitably constrained by the cultural assumptions of one's own thinking, such as the assumption that literature is wholly ascribed by printed texts. These assumptions, even with the best intentions, can be difficult to expunge.[5]

Extending Wendt's rationale to this study crystallises a challenge for the case study engineers. In their dealings with another cultural symbol - technological artefacts of western origin - the case study accounts suggest that these "symbols" can be just as impervious to the scrutiny of the uneducated as the Samoan *tatau*. As the process of adapting technologies to a local context needs to account for the stringent requirements of the technological artefact, the consequence of ignoring these requirements appears straightforward - the machine will eventually break down. The question, whether such a break down will throw into disarray the process of technology-based change, is dependent on the degree to which a working machine is factored into these processes of local society. As seen in the case study accounts with the parliamentary broadcast

[5] This observation applies to this study also. Referring to the arguments of Metcalfe (1996) and Alvesson (1995) in Chapter 4, the need for the scrutiny and approval of a knowledgeable audience becomes more apparent in this context.

transmitter, demand for working equipment can be very high. In the case of "substandard" levels of technical quality of tape recorders, people may also be content with a "half-working" machine. Or perhaps, people may be required to revert to practices which existed before the machine arrived, as the example of the digital audio computer suggests.

The study therefore reasons that technological capability is socially constituted in both the determination of goals to which technologically capable practitioners are directed and in its development - that is, the resources the organisation and community provide to facilitate the problem solving efforts of the engineers. The constraints of smallness, in terms of limited budgets and inadequate staff numbers within a context of isolation, and the particular responses individuals and organisations make to these constraints, can be seen as contributing to the unique character of capability development. The theme of resistance to change therefore, may not necessarily represent resistance to "reasonable" or "rational" development strategies but rather is more likely to refer to specific responses made to ensure that local values and customs are maintained within the contingent and sometimes hostile circumstances of the global environment.

7.4 PACIFIC ISLAND ENGINEERS: AT THE CUSP OF TWO CULTURES

Hofstede (1984, pp. 110-147) argues that societies have developed different ways of countering uncertainty and this is reflected in the nature of organisations which are formed within these cultures. On that basis, some may be tempted to identify the organisational constraints on problem solving identified in the analysis as a manifestation of some innate feature of local culture. For example, the unwieldy nature of the purchasing system could be interpreted as being a product of local culture where authority is held by those of rank. Similarly, the restrictions placed on the use of the telephone and

fax machine for international calls can be associated with local custom in which communication with other social entities is performed by those in authority, such as chiefly orators. Alternatively, one could investigate the degree to which the patronising attitude of New Zealand administrators during colonial times (Alailima, 1988, p. 262) is still embodied in the administrative systems in use today. Then again, perhaps a better explanation is the more practical one of the pressing need to ensure that strict control is maintained over limited financial resources in an isolated environment.

While it may be possible to implicate factors which are specific to these communities in constraining capability development, there is also reason to suggest that local culture is dynamic enough to generate and incorporate change, if the need is great enough. The earlier example of the difficulties the chief engineer had with gaining approval for the chief technical officer position represents a case in which the system was seen to eventually respond to this situation and change. Therefore, it seems prudent not to assume that the nature of these circumstances are static and not amenable to change.

Rather, it appears that the process of the adaptation of technology can be viewed as a community-wide problem solving project which incorporates issues wider than the concern of engineers and their responsibility for keeping machines and equipment operating. Even though broadcast technology is globalised to the extent that it can be found in many locations across the world, the case study accounts reveal that there are some unique aspects to this project within this community. Therefore, it is claimed that the adaptation process is unique and the process innovative in that the purposes and goals to which this technology are put are not necessarily those of other societies and the adaptation process is subject to the influence of local factors which can also be unique and unpredictable.

On this basis, and assuming that there is a requirement for these artefacts to work within this organisation, it is argued that engineers play an instrumental role in adapting these

technologies to the local community. The engineers' relationship with their organisation and the machine suggest that they are engaged with two separate cultures. The organisation, as a creation of local circumstances, can be seen as representing the demands of local culture. On the other hand, the concept of engineering culture advanced by Forsythe (1993, pp. 448-450), is seen here as a necessary resource to enable the engineers to respond to the many "yet-to-bet" discovered truths of machines and equipment. Hence, this thesis ultimately portrays the engineers as standing at the cusp of two cultures, their own and the engineering community the technological artefact implies. Consequently, it maintains that a proficiency in participating in both of these cultures is a necessary quality for these engineers.

While the study has identified instances in which the organisation has been instrumental in promoting the engineers' capabilities, the study is also able to identify areas in which the organisation is able to make further contributions. On this point, the findings of chapter 6 identify the lack of participation of these engineers in networks with other engineers outside the organisation as a critically important issue that the organisation should address. From an information perspective, access to sources of information, more particularly, the "hard to get" information derived from experience, is an important factor in the process of problem solving and hence capability development. The analysis, therefore, points to a need for these engineers to be given more authority to command the use of resources outside their organisation.

The previous analysis of information transactions maintains that the engineers are lacking in sufficient amounts of appropriate "currencies" to "pay" for problem solving information. The kind of "currencies" in short supply were revealed as being more than money, important as that may be. Hence, the concept of authority includes a number of issues which extend beyond the need for just more financial resources and better telecommunication technologies. For example, the procedures leading to the procurement of goods could be designed to allow a more direct interchange between the engineers and

equipment suppliers. Such an initiative would require that the engineers be given more authority to administer budgets and order equipment. One therefore anticipates that, as a by-product of this exchange, the establishment of trust and personal relationships required for productive information sharing relationships might follow. As a necessary complement to this measure, the ability to engage in communication with these equipment suppliers without scrutiny from the organisation is another initiative the case study engineers would benefit from. In this respect, cheaper telecommunication services in the Pacific emerges as another important issue integral to the further promotion of capability development. Another aspect to the need for greater authority concerns the nature of information the engineers themselves have to share. The opportunity to work on modern equipment allows greater opportunity to develop knowledge which is of more relevance to equipment suppliers. Expertise in outmoded equipment is of limited significance to these suppliers as their current focus is naturally on current products and their associated problems. Once again, the response to this problem is a need for more money, but behind this problem stands a rationale based on the unusual characteristics of information which perceives such issues as vitally important to the development of technological capability in these engineers. From this perspective, the desire of appropriate technology proponents to provide old technology on the basis that it is less complex also works against the establishment of productive information sharing relationships on which to better promote capability development.

7.5 CONCLUSION

In determining a role for the engineers which is subservient to local interests, the thesis takes issue with a common underlying theme of dominant critiques in Pacific Island development. Noting the considerable economic and cultural power embodied in technologies which emerge from industrialised countries, the thesis argues that both

modernisation and dependency perspectives overlook the power of indigenous communities in the Pacific to direct, shape and contextualise imported technological artefacts in accord with local values and customs. The organisation is argued to be a product of the unique historical and political circumstances of individual communities. The engineer appears within this context as an important player in directing modern technology to goals which are appropriate to local mores.

Technological capability is argued to be socially constituted in both the goals to which these engineers are directed and the extent to which the organisation facilitates the problem solving efforts of these engineers. The thesis therefore argues that the diffusion of imported technologies is a uniquely localised process of learning and discovery rather than one of just applying established principles developed elsewhere. In that the organisation is argued to make demands for the machine to work in a manner which is submissive to local values, the dilemma for these engineers is that the machine also demands a set of relationships with other experienced engineers outside the organisation in order to ensure its continued operation. Hence, the thesis ultimately portrays the engineers as standing at the cusp of two cultures, their own and the relationships the machine imply. The thesis maintains that a proficiency in participating in both of these cultures is necessary for Pacific Island engineers and their organisations. The chapter concludes with recommendations describing ways in which the organisation is able to better assist the engineers in this important project.

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Chapter 8

Technological Capability from an Information Perspective

8.1 INTRODUCTION

This investigation into Pacific Island engineers has determined that problem solving is of fundamental importance in coping with the vagaries of equipment behaviour. The organisation emerges from this study as an influential actor which determines to a large degree the capacity of its engineers to respond to situations of uncertainty. Furthermore, the organisation is found to be less a reflection of organisations which use similar technologies in western countries and more a creation of the circumstances at a local level during the adaptation of western technologies. This chapter is devoted to developing a theoretical perspective that is able to incorporate an organisation which uses western technology but is primarily directed to serving the local interests of Pacific Island communities.

The chapter begins by revisiting the two studies of technological capability to make final assessments about how well these studies respond to the particular circumstances of the organisation in this case study. The discussion reasons that insufficient attention is given to the influence of uncertainty on the case study subjects. This is initially associated with equipment breakdown. The discussion proceeds to link the concept of uncertainty to the broader process of adapting foreign technologies and argues that the potency of local culture in this process should be given greater recognition. The need for an analytical framework which is not burdened by the value-laden notions of "development" is most

clear. On this basis, the chapter explores the concept of social transformation (Castles, 1999) as a critique which attempts to resolve this tension between the influence of global technologies and local autonomy. The instrumental role attributed to both information and information technology in this process suggests that Macdonald's information perspective is amenable to wider application.

8.2 INCORPORATING THE PACIFIC ORGANISATION INTO TECHNOLOGICAL CAPABILITY THEORY

By drawing on the accounts and analysis contained within this case study research, a number of conclusions can be made about the two studies of technological capability (Enos, 1991; Bell and Pavitt, 1993). While the analysis of research data confirms the literature reviews' preference for Bell and Pavitt's (1993) study for the reason that it is able to achieve more purchase on the problem of capability development of engineers, the following discussion indicates the need for further work in accommodating the case study organisation which is shaped by the community in which it is located.

The fundamental difference between the two studies of technological capability (Enos, 1991; Bell and Pavitt, 1993) lies in their treatment of the environment. As outlined earlier, Enos (1991, p. 2) views the environment as variable and technology given. Bell and Pavitt (1993, pp. 165 & 202), on the other hand, identify a number of enduring features to the social and physical environment which can be used to explain the differences in performance between countries and organisations in their use of technology. The literature review explained that the implications of these alternative approaches to the environment was most clearly reflected in the differing emphasises these authors placed on the role of experience in the development of technological knowledge.

The literature review concluded that while both studies outlined an important role for experience in enhancing the use of modern technology, its relationship and relative importance to theoretical knowledge differed markedly between the two studies. While Enos (1991, p. 151) viewed experience as something which '...tended to emerge in pursuit of greater output...', Bell and Pavitt (1993, p. 166) outlined a more separate and instrumental role for experience and communication in the production of tacit knowledge. The use of growth models by Enos (1991, pp. 19-55) indicated an acceptance of fixed relationships between "system" inputs and outputs. The relationships drawn by Enos between theoretical knowledge and experience was argued by the thesis to be linear with acquisition of the former leading to the development of the latter. In contrast, Bell and Pavitt (1993, p. 166) argued that experience and communication represented important components of technological capability which were distinct from the theoretical attributes of technological knowledge. The need to draw the distinction between the codified and tacit aspects, from their perspective, is a reflection of the complexity of dealing with modern equipment and the uncertainties derived from its deployment in the organisations of developing countries. Accordingly, both studies outlined attributes for the organisation to engender technological knowledge development.

In light of research undertaken in this thesis, the greater emphasis that Bell and Pavitt place on learning through experience and communication within and between organisations responds positively to the identified difficulties of the case study participants in acquiring problem solving information. The uncertainty associated with learning-by-doing in the case study analysis is in accord with Bell and Pavitt's (1993, p. 170) assessment of learning-by-doing when they state that it is not sufficient in itself for the development of technological capability. The absence of communication linkages between the case study participants and equipment suppliers would be of significance to Bell and Pavitt (1993, p. 168) who observe that such linkages are necessary for the diffusion of technology.

Referring to the study conducted by Enos, it is difficult to resolve the obvious contrast between the certainty Enos associates with the use of technology and the uncertainty experienced by the engineers as recorded in the case study accounts. Use of the term "experimentation" by Enos (1991, p. 113) to describe the problem solving activity of practitioners suggests that these practitioners are engaged in a deductive process of hypothesis testing. This does not adequately capture the experience of the case study practitioners who often experience difficulty in merely defining the nature of the problem they are seeking to solve. No explicit recognition of this basic reality is found within the study conducted by Enos.

The extent to which Enos (1991, pp. 113, 122 & 175) assumes he is able to separate the organisation from local society is found to be misguided in light of the case study accounts which reveal that the radio station is integrated with, and sustained by, the broader community. Enos portrays two worlds in his study: a technical world in which ideology plays no role and capability flourishes, and another where the purported vices and imperfections of human nature stand opposed to technical excellence. Hence, Enos's portrayal of the organisation as an institution based on notions of a science laboratory stands in considerable contrast to the case study organisation which is observed as being wholly immersed in the social milieu. Whether such an organisation-cum-laboratory is more preferable for the development of technological capability is largely beside the point. For the practical purposes of the case study participants, the social environment in which these engineers work has many enduring features which cannot be explained away by disparaging references to ideology or self interest.

In contrast, Bell and Pavitt's acknowledgment of the "real-world" circumstances of practitioners, such as the need to respond to the complexity of modern technological artefacts or the influence of history, allows more penetrating inroads to be made into the question of capability development, as far as the case study engineers are concerned. The

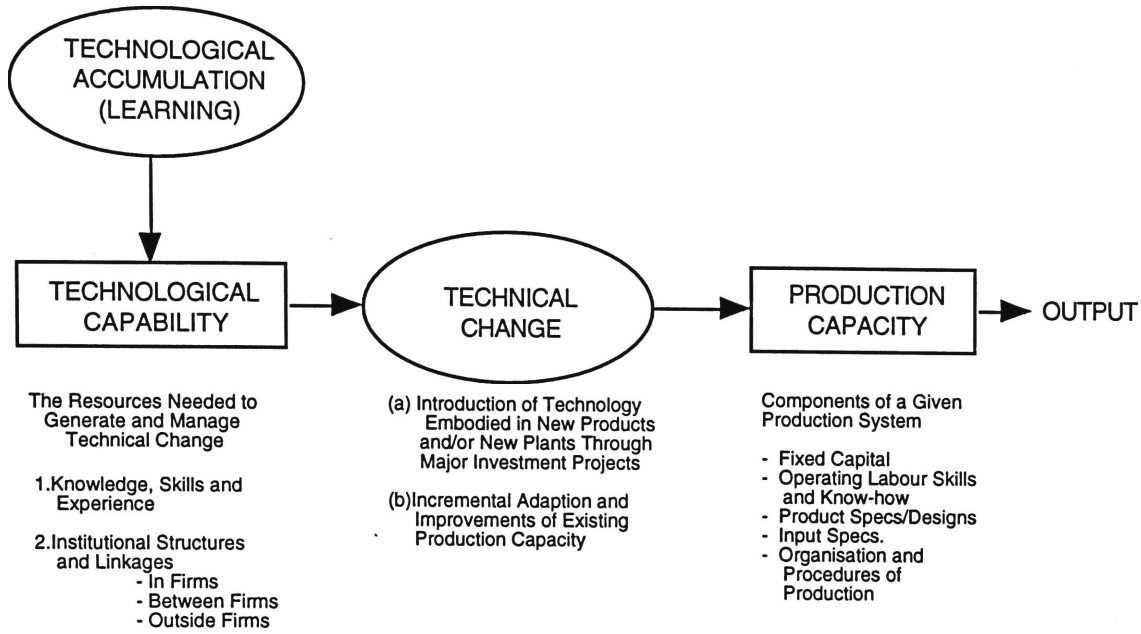
complicity of the radio station in constraining problem solving supports Bell and Pavitt's assertion that the organisation is an important site for the development of technological capability. The identification of history as a significant factor explaining current and future technological capabilities was found to be important in understanding the significance of the radio station's poor record in retaining staff during the 1980s - the consequence being that this experience has been lost to the organisation and there are now few opportunities to draw upon it. Bell and Pavitt's recommendation that organisations make specific investments for the development of tacit knowledge is another aspect of their study which can be applied to the case study organisation. The purpose of such an "investment" as far as the case study engineers are concerned relates to the need for greater contact with knowledgable practitioners working for overseas equipment suppliers. The thesis recommends that nature of such an "investment" is one in which the radio station extend more authority to the engineers so that they will be better able to develop productive information sharing relationships. This advice is also in accord with Whalley's (1986) study, where he argued that engineers required freedom and trust in order for them to carry out their discretionary tasks, and Orr's (1996) study, which identified the organisation's tacit approval in allowing the technicians the freedom to informally communicate and interact as being of critical importance to their ability to resolve machine problems.

However, the case study accounts and the analysis undertaken in this research raise doubts as to whether Bell and Pavitt's study is able to fully comprehend the significance of "smallness", "isolation" and "resistance to change", the three themes used to summarise the particular conditions relevant to the Pacific region. This disparity is apparent in the distinction Bell and Pavitt draw between day-to-day production activities, which are aimed at maintaining existing levels of efficiency, and the activities associated with technical change, which are needed to achieve higher levels of efficiency. Indeed, the advice delivered by Bell and Pavitt is aimed at achieving technical change rather than maintaining daily production (p. 159). The difficulty the thesis has with these

distinctions is that the emphasis on technical change as a planned activity serves to discount a major proportion of the experience of the case study engineers, who view the unplanned changes wrought by the combination of equipment breakdowns and community demands as the most taxing on their knowledge and emotions.

The thinking behind Bell and Pavitt's definition of technical change is reasonable in that they wish to advance an understanding of technological capability that is concerned with attaining higher levels of economic efficiency. Yet, they note that the majority of developing countries struggle to maintain even static levels of efficiency (pp. 187-189). The emphasis given to technical change activities in contrast to day-to-day production activities by Bell and Pavitt has the effect of drawing inquiry away from the area in most need of attention. The case study accounts reveal that, as far as the case study engineers are concerned, there is little reason to drawn distinctions between technical change activities (such as expanding the engineer's outside broadcast capability) and technical maintenance activities (for example, equipment repair). Both involve the challenge of coping with uncertainty. As uncertainty does not figure prominently in Bell and Pavitt's discussion about day-to-day production activities, the difficulties of maintaining existing levels of production activity are understated.

In response, Figure 8.2 has been formulated to explicitly recognise uncertainty as an influential determinate over day-to-day production activities. (For the reader's benefit, Figure 8.1 is a reproduction of Bell and Pavitt's diagram detailing capability development processes, as depicted in Figure 2.1). In view of the particular constraints imposed by "smallness" and "isolation" on technological knowledge development, the "institutional structure and linkages" listed in Bell and Pavitt's figure have been diagrammatically detailed as information flows within and outside the organisation to reveal the interactive and dynamic nature of problem solving. Three forms of information flows are detailed in which external information is recognised along with learning-by-doing and information gathering within the organisation. In combination, the modified model depicted in



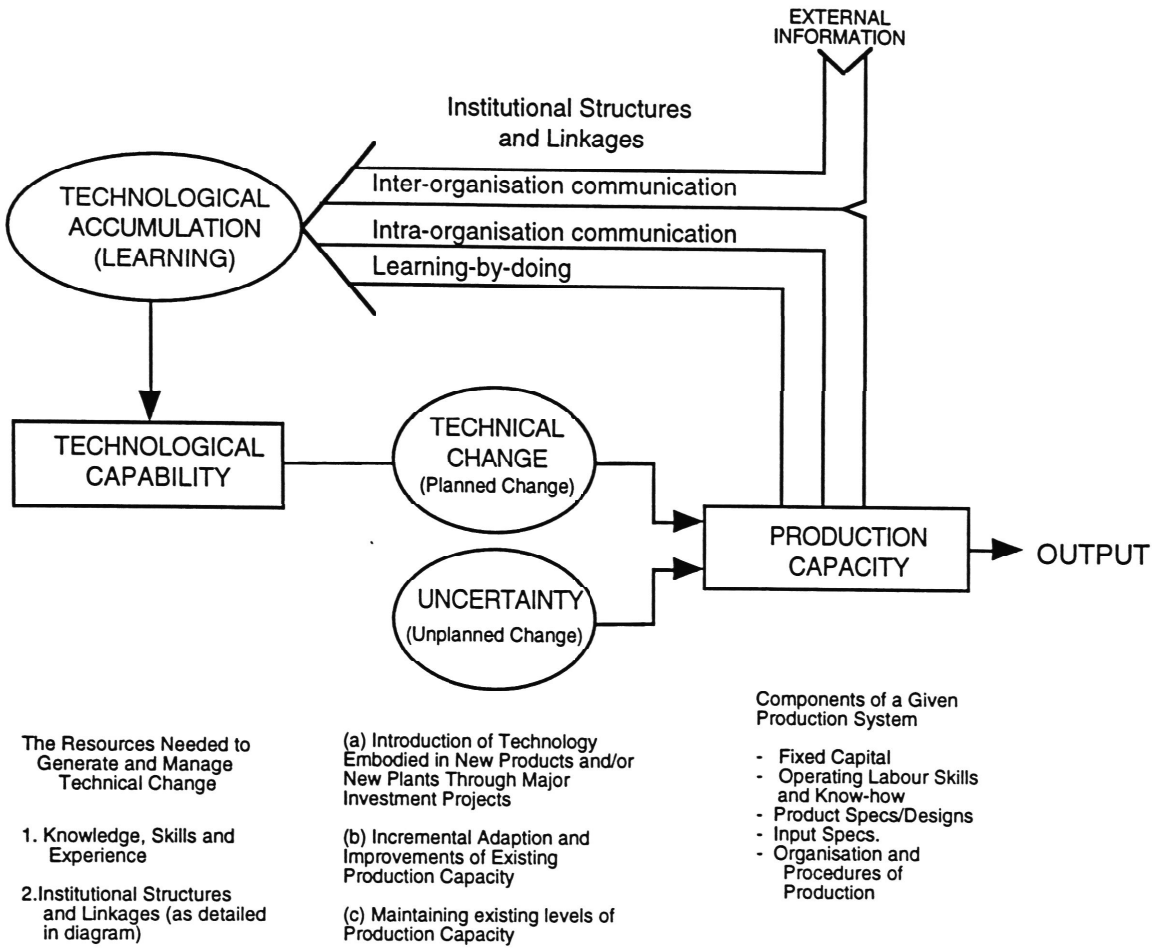
Technological Capability Development from Bell and Pavitt's Perspective.

(Bell & Pavitt, 1993, p. 164)

Figure 8.1

Figure 8.2 goes some way to granting analytical recognition of the themes of "smallness" and "isolation" because it responds to the fundamental difficulties experienced by the research participants - the uncertainty associated with unplanned change and, because of the limited opportunities for communication within the organisation, the need for external information.

The thesis identifies barriers to the acquisition of external problem solving information. Their existence is related in part to the need for viable commercial relationships with overseas equipment suppliers. Among the difficulties in the establishment of such relationships are factors which can only be explained by social processes at a local level. Insufficient recognition of these processes and the consequent influence they have on the transfer of problem solving information is likely to lead to a deficient understanding of factors governing technological capability development. The thesis maintains that the use of economic efficiency as the sole basis for determining technological capability



Technological Capability Development from an Information Perspective.

(Adapted from: Bell & Pavitt, 1993, p. 164)

Figure 8.2

development, as demonstrated in Bell and Pavitt's study, will similarly lead to a limited understanding of the processes which contribute or detract from capability development. It is also from this perspective that the theme "resistance to change" is revealed to be an unsatisfactory description of local society's response to the introduction of western technology. The thesis descriptions reveal a dynamic and uniquely localised process of change which markedly effects the ways in which these technologies are adapted and more importantly, influence the problem solving of the case study engineers. The goals motivating organisations in developing countries are many and are shaped by the demands of the local community among which the goal of economic efficiency may have

strenuous competition. While this raises questions about the economic viability of operating modern technologies in such contexts, the thesis agrees with commentators such as Hill (1988; 1994) who argue that more important to the sustainability of these technologies in the Pacific region is the need to attain viability in a cultural sense where the use of modern technology strengthens rather than diminishes existing social relationships. This study's response is to argue that such viability is partly dependent on a "multi-cultural" engineer who is aware of the informational constraints in both the local and overseas sphere and has the resources to effect the transfer of problem solving information.

As regards the research agenda of Cooper's (1994) identified in the thesis introduction, the thesis provides qualified support for an approach which is informed by studies of innovation from developed countries on two counts. Firstly, the organisation is found to be a suitable analytical unit for understanding technological capability development in the Pacific region. Secondly, the significance which is attached to the codified and tacit attributes of technological knowledge is of fundamental importance in understanding the difficulties of the case study engineers. In particular, the rationale developed by Macdonald in the course of his study of innovation in a number of different contexts is found to be of significant benefit when analysing capability development in the Pacific region.

Yet, the thesis invites further questions about the nature of innovation within the Pacific organisations and the degree to which these processes are given due recognition in studies of innovation in western organisations. More profoundly, the case study suggests that theory which assumes a central place for western goals and values in non-western societies is likely to lead to an insufficient understanding of change which is built on the use of western technology in these communities. It is for this reason the discussion proceeds to explore work occurring outside innovation studies which is concerned with developing an analytical framework which is not dependant on western-centred concepts

of development. Interestingly, it will be argued that Macdonald's information perspective may have a role in this area of discourse also.

8.3 LOOKING BEYOND DEVELOPMENT DISCOURSE

In identifying the need for theory which is able to account for an organisation whose creation is heavily influenced by its historical and contingent circumstances, but is also shaped by its interaction with foreign technology suppliers, the thesis provides support to those who are working towards an analytical framework which is not dependent on western-centred ideas of development. An early indication of such support can be found in the use of Thomas' (1991) historical-anthropological investigation in the literature review (Chapter 3) to establish a counterweight to both modernisation and dependency theory. Thomas' findings were advanced on the strength of evidence from Pacific based commentators who argued that the potency of Pacific cultures was not adequately reflected in theoretical models of development. In terms of the broader debate between the relative importance of foreign domination over the autonomy of local culture, the case study endorses calls by commentators such as Castles (1999), who argue that the value-laden concepts associated with the term "development" should be laid to rest. However, as Castles (1999) also points out, the task of developing an alternative critique to replace development discourse is an onerous one.

Certainly, the value of Thomas' (1991) perspective for contemporary analysis is compromised by the fact that exchanges in the Pacific region today are increasingly mediated by information and communication technologies rather than the sailing ships characteristic of Thomas's study. Giddens (1991) argues that the defining difference between contemporary societies and those of the past is that international relations (political, economic and cultural) have been compressed in both time and space by such

technologies, leading to what he describes as the primary characteristic of modernity, globalisation (Lie et. al., 1996, pp. 3-4; Castles, 1999, p. 9). There are difficulties associated with the concept of globalisation however, because a definitive understanding of this phenomenon has not been resolved. Some areas of globalisation discourse resonate with strains of dependency theory. For world systems theorists, globalisation is defined by the increasingly internationalised nature of economic and cultural activity, a trend which they celebrate with little concern for the interests and autonomy of poorer countries (Lie et. al., 1996, p. 3; Castles, 1999, p. 4). On the other hand, there are those who caution that the concept of globalisation is a multifaceted one. Citing the work of Holland, Lamberton (1994, p. 23) lists some important and divergent features of the global economy: '...there are many dispersed units acting in parallel, there are rarely any global controls; the economy has many levels of organisation and interaction; systems adapt in a climate of perpetual novelty; and the economy operates far from an optimum...'. Lamberton (1994, p. 23) goes on to conclude:

> in such circumstances, there will be an important role for accumulated experience, affecting both new technology and the interactions between units. In other words, culture must find a place in this analytical framework.

In contrast to the emphasis on the global, Lamberton points to the importance of localised knowledge generated out of the experience of dealing with the specific and localised uncertainties of this global economy. Lie et. al.'s (1996) descriptions of the work of UNESCO in the Pacific region reflect similar underlying sentiments. While global cultural flows have been facilitated by the increasing penetration of telecommunication technologies, they argue that the interpretation of these flows must ultimately occur within the context of the local (Lie et. al, pp. 14-15). UNESCO's role in the Pacific region is to promote opportunities for local interpretation and reflection through the provision of communication technology infrastructure, human resource training and other resources to enable the creation of local media content and regional exchange (Lie et. al., 1996, p. 20).

Resolution of this tension between the global and the local is for Castles (1999) the primary task which needs to be addressed in the formulation of an analytical framework to replace development discourse. Castles (1999) describes the process as one of social transformation and is keen to know the other part of the globalisation story - the change that is occurring at the local level and which is not adequately described by simplistic "cause and effect" relationships that occur as a result of global "forces" (p. 13-14). While he acknowledges that the term "transformation" is hardly new, the purpose here is to develop an analytical framework which is able to simultaneously comprehend the global and the local. So he defines the process of social transformation as a '...complex two way process of mediation...' (p. 14) which is '...mutually reinforcing and *reflexive*... ' [italics in original] (p. 8). This reflexive relationship is one in which '...the effects of globalisation are mediated through the specific conditions of each locality, community or society...' and distinctions between cause and effect are less important than understanding the experience of the global in the local.

In outlining this research agenda on social transformation Castles draws from the work of Manuel Castells (1996, 1997, 1998). Castells (1998, p. 336) describes the current changes in world societies as being factored on information technology, the collapse of capitalism in the West and statism in the former USSR and the emergence of movements united by a global consciousness on issues such as feminism, the environment, human rights and so on. He argues that contemporary societies are at the beginning of a new epoch, the Information Age, which he characterises as being dominated by the existence of two macro trends: '...the globalisation of the economy, technology and communication; and the parallel affirmation of identity as a source of meaning...' (Castells, 1998, p. 311). Within this vision of a new form of informational capitalism is the existence of '...multiple black holes of social exclusion...' which allows countries or even particular locales to be selectively excluded from productive involvement in this new form of economic activity (pp. 161-165). The reason for this exclusion relates to the

value of an individual's skills to an economy increasingly factored on the transfer, manipulation and value adding of information.

Lamberton (1994) also views the central question facing countries, whether "developed" or "under developed", as being centred on information. Lamberton is primarily concerned with asymmetries in both information and capabilities to use such information. In contrast to Castells, Lamberton (1994, p. 23) is more circumspect in attributing too much significance to the increasing use of information technology or the apparent convergence of telecommunications and computing (mostly for the reason that there is still much to be determined about the nature of change factored on the use of increasingly sophisticated information technologies). Rather, he argues that development strategists need to devote greater attention to both the central role of organisations and their informational abilities. Lamberton (1994, pp. 12-13) argues that organisations display differing characteristics in their use of information and this is influenced by their histories. He maintains that past and prevailing circumstances of the organisation are influential in determining what information is present and the competencies which are subsequently developed to use this information. So important are these organisational capabilities to national development, Lamberton (1994, p. 20) suggests that the organisation should be considered along with roads, dams and telecommunications and the like as an essential component of the infrastructure needed in developing countries.

The link Lamberton establishes between the information handling abilities of the organisation and the broader social context of the organisation suggests a more ambitious rendering of strategies for technological capability development which incorporates the informational ability of the individual and the organisation. Essentially, the perspectives of Castells and Lamberton can be seen to converge on the question of how to place the information resources of the global economy into the hands of local practitioners. It is here that a more utilitarian role for Macdonald's information perspective is perceived in the broader theoretical issues of technology transfer, particularly as it relates to the

mediating role the organisation performs in situating such technologies within the local environment.

The use of Macdonald's information perspective as an analytical tool to better understand the experience of the case study participants suggests that such an approach is able to yield valuable insights of the barriers that prevent the transfer of information to the case study engineers. Of most significance is the manner in which an information perspective is able to respond to the locally determined nature of problems through its capacity to focus on the problematic situation and simultaneously recognise the significance of problem solving information which is external to the organisation. Furthermore, Macdonald's information perspective shifts the spotlight of capability development from an individual ability, as important as that may be, to the corporate ability of the organisation to acquire this information and the relationships that exist with overseas organisations, which have been found to contribute to the dynamics governing the transfer of problem solving information.

The discussion moves beyond a technology-centred discourse to one in which attention is devoted to information and factors associated with the transfer of information. Macdonald's information perspective enables a better understanding of local problem solving in a global context in three ways.

Firstly, by viewing, the technological artefact as a device in which information is embodied (Macdonald, 1983, pp. 26-31), it is possible to view the process of change in terms of informational processes rather than in terms of the visible and tangible artefacts of technology.

Secondly, in conjunction with the dominant picture of "cultural flows" being delivered to the Pacific Islands via the information highways (or byways) of global telecommunication technologies, the kind of informational activity

promoted by Macdonald is more refined and strategic in its use of this burgeoning information infrastructure as individuals gain the necessary skills and resources to seek out and acquire information required for the resolution of local problems.

Thirdly, he identifies the organisation as being central to this informational capacity of the individual. The organisation ideally provides these individuals with the necessary wherewithal to effectively respond to the dynamics that govern the transfer of external information over this information infrastructure.

In summary, Macdonald's information perspective allows within one analytical framework the incorporation of the locally determined goals the organisation seeks to fulfil along with recognition of the necessity for external linkages to enable the ongoing operation of globalised technologies.

Manuel Castells (1998, p. 164) portrays the Pacific Islands as being firmly within a '...black hole of social exclusion...' such as he describes. Encircled by the powerhouse economies of a number of Pacific rim countries, he perceives the plight of Pacific Island countries as that of living in abject poverty while social cohesion is undermined by tourism. The case study details a brighter picture with an active process of negotiation over the pace and direction of change factored on western technology taking place, suggesting a high degree of robustness in Pacific communities. The organisation in this case study acts as an interface between the global and the local. Its informational ability emerges as being critical to the performance of its employees in meeting the challenges posed by the difficult task of situating global technologies in the social and physical environments of its local community. Extending the analysis of the informational processes of this organisation to other sites of interchange between the global and the local represents a rich agenda for further research.

8.4 SUGGESTIONS FOR FURTHER RESEARCH

This case study investigation outlines a number of areas for further research. Emerging most strongly from the analysis is the need for research methodologies which reveal and scrutinise the actions of individuals or organisations without needing to compare their attainment of goals with the attainment of goals of organisations from western countries using similar technologies. While there is obviously some scope for the knowledge of western practitioners to assist in the adaptation of western technology in Pacific based organisations, the project of these organisations is unique and in that sense, foreign expertise is only ever going to partially meet the needs of individuals and organisations in the Pacific. So, as practitioners in the Pacific will be confronted with situations that are unique, the concept of innovation is important for technological capability development research in the Pacific region.

The other overarching issue that the case study identifies as critically important is the two part nature of technological capability where individual ability needs to be strongly complemented by an organisational ability to provide practitioners with the authority and resources to respond to problematic situations. By endeavouring to understand how to better promote the informational ability of the individual it is recognised that the organisation and the broader social environment both play a critical role. Because of the particular difficulties posed by "smallness" and "isolation" in the Pacific context, the need for specific attention to the development of informational ability is highlighted. More complex than just a question of overcoming distance, the finding that intangible elements contribute to establishing viable information networks suggests the need for practitioners who are adept at finding, acquiring and using information - that is, people who are aware of the constraints which prevent information transfer and the role of informal information networks in the transfer of tacit knowledge. This raises the question of whether the provision of education and training based on "equivalent" positions in Australia or New

Zealand can adequately equip prospective practitioners from the Pacific with sufficient information-using skills. To the extent that trade, technical and professional education qualifications imply different degrees of information-handling skills (Gibbons and Johnston, 1974, pp. 236-239), the thesis asks whether these skills are adequate in the information-hostile environment of the Pacific region, particularly at the trade and technical levels.

The thesis also recognises a broader set of challenges in the area of telecommunication policy development than is often granted by the established literature. Current policy falls short in catering for the information related difficulties of practitioners. If one looks at the way telecommunication companies have traditionally valued information, that is by using the formula of distance versus time versus bandwidth, it can be seen that this does not account for the value that the information represents to the end user. Furthermore, the profitability of these telecommunication companies appears to have narrowed the focus of politicians and managers to view telecommunication departments primarily as sources of revenue. As past ITU Secretary-General Pekka Tarjane (1998) notes, some have been so short sighted as to signal their reluctance to facilitate Internet growth on the basis that email represents a threat to voice and facsimile telephony. A more expansive vision of this important area needs to be articulated by information based research.

A policy document on communications drawn up by telecommunications ministers from the South Pacific Forum is one example of policy formulation which falls short in accounting for the dynamics that govern the transfer of information (SPF, 1999). The document attempts to respond to the growing popularity of the concept of a Global Information Infrastructure (GII) within which a vision for the Pacific Information Economy is described as '...enabling all citizens to take part in the opportunities brought home by the global information economy...' (SPF, 1999, p. 4). Yet, the focus of the document is technology and regulation - the main theme being the need to align telecommunications policy to the recommendations of the World Trade Organisation

(WTO). While the document acknowledges the fundamental problem of information asymmetry, noticeably absent is any mention of how the reform process directly contributes to the "value adding" of information, something which must conceivably occur if the vision of a Pacific information economy is to be realised.

The insights delivered by this thesis suggest that greater research attention needs to be devoted to the ways in which telecommunication infrastructure accounts for the transfer of codified and tacit knowledge. While it is accepted that on-line technologies are eminently suited to the transfer of codified information, the communication of choice for the interactive nature of tacit knowledge transfer, (in the absence of face to face communication), is voice communication or email communication (Hinds et. al., 1995, pp. 388-389). While email is cheap, traditional voice communication is still horrendously expensive in the Pacific (Hildebrand, 1999, pp. 32-33). Hence, it is possible that email may have a more instrumental role to play in terms of transferring experientially based knowledge than the world wide web - assuming that there are other people who are willing and able to provide such information.

There is a need therefore, for telecommunication providers to give greater attention to the information-related difficulties of the end-user. Most significant is the need for a revision of how the concept of network is defined. While the tangible infrastructure of communication networks is dominant in current discourse, the concept of network espoused by this thesis attempts to capture the intangible nature, (such as relationships between individuals or organisations, common interest and trust), and view these attributes as being necessary to cope with the unusual characteristics of information. Macdonald (1998b, p. 301) suggests that if telecommunication policy makers are serious about achieving a more fundamental capability with what end-users are trying to do, then their understanding of network needs to accommodate the uncertainties of dealing with the intrinsic value of information and the need for information transactions which enable information transfer.

In identifying the critical need of the case study engineers for problem solving information and the networks to provide such information, a more pressing and practical focus for a research project has emerged - the need for greater communication among Pacific Island broadcast engineers over issues they have in common. The 1997 Report of the PIBA Engineering Committee contains accounts by chief engineers from other Pacific broadcasting organisations that show some commonality of experiences (PIBA, 1997). The difficulties of arranging for spare parts and resolving difficult technical problems are two examples and suggests a basis for a strategy which aims to link these engineers using the Internet with the goal of creating an on-line community. Such measures are being used successfully in rural and isolated communities in Australia to link marginalised groups such as rural women and indigenous Australians (Simpson et. al., 1998). The lessons from this project relate to the importance of intangible network elements which Simpson et. al. (1998, p. 163).describe by the term '....social infrastructure...'. Understanding how this infrastructure is created and facilitated represents an ongoing aspect of research into the use of telecommunications to facilitate social interaction and problem solving.

8.5 CONCLUSION

In conclusion, this thesis was primarily concerned with identifying ways in which technological capability development in a group of Pacific Island engineers was facilitated or constrained by three thematic factors of the Pacific region - "smallness", "isolation" and "resistance to change". By linking the interpersonal communication which occurs between engineering practitioners to the process of knowledge development, the thesis identified ways in which the organisation has constrained knowledge development by limiting the participation of its engineers in communication relationships with experienced

engineers overseas. The unique factors shaping this organisation in terms of the constraints of smallness and isolation as well as the locally determined goals it was endeavouring to fulfil were found to have been given inadequate recognition by the main stream literature of technological capability development. The use of Macdonald's information-based framework was effective in responding to the unique attributes of the case study organisation because of its emphasis on problem solving and the dynamics governing the transfer of information. In particular Macdonald's framework crystallises the need for a definition of communication network which accounts for the end-user's difficulty in acquiring problem solving information as well as the uniqueness of the social circumstances in which these individuals are required to work. Emphasis on the intangible aspects of active communication relationships maps out a research agenda which focuses on informational processes rather than on the tangible components of technology. The thesis argues that Macdonald's information perspective has the potential to give a better understanding of the tension between the global and local aspects of technology diffusion. The most critical research challenge this thesis identifies is how to best place the resources of the global information infrastructure into the hands of the local practitioners to enable them to carry out the innovative task of situating global technologies in the local circumstances of their communities.

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Appendix 1

Miscellaneous Documents

APPENDIX 1.1

Letter of Support from the Pacific Island Broadcasting Association (PIBA).

Fax Transmission

PIBA Engineering Committee
Pacific Islands Broadcasting Association
PO Box 116, Port Vila, VANUATU Fax (678) 24252, Tel (678) 24250
e-mail: paonews@vanuatu.com.vu

Attn.: William Tibbeu
Fax 0061 42 682703

From: Hendrik Kettner

No. of pages: 1 Date: 6/5/97

Dear William

The majority of public, as well as private Radio and TV broadcasters in 13 Pacific Island Nations is represented in our organisation. Out working areas, just to mention a few, are co-operation between and training of staff of our membership.
Performing these tasks is difficult at times and very expensive considering the vast distances between the Pacific Islands.

The above is probably not new to you as you have been engaged on our behalf in a number of technical cosultancies and training exercises in various places of the Pacific. The feed-back from your activities received at our office has been excellent and we intend to use your services also in the future.

Recently, we have learned about your intended study project and we sincerely hope that you will still have the time to co-operate with us in the above mentioned areas. We understand that your study will also examine possibilities or applications for new digital technologies in terms of training and co-operation, in particular for technical broadcasting personnel in the Pacific.
As we are very interested in this area, we highly welcome your study and we whish you all the best in your efforts.
At the same time, if it appears to be of any use for you, we would like to offer our support in terms of access to information available in our office.

Please feel free to contact me any time.

Kind regards

Hendrik Kettner
Technical Coordinator

TIB70506.WPS

APPENDIX 1.2

Samoa Broadcasting Service Station Profile

Samoa Broadcasting Service - Station Profile.

Radio 2AP (WM-2AP) began broadcasting from its studio at Apia, Western Samoa on 5 August 1947. The 2kW A.M. transmitter made by AWA (Amalgamated Wireless Australia) on a frequency of 1440kHz was remotely located on a nearby mountain called Afiamalu. Due to the absence of man-made electrical interference the transmitter power was just enough to cover the 2,934 sq.km island group.

The purpose of the station was to allow the governor of the Colonial Office of the time to broadcast weekly messages to the population. In addition to this other messages from the administration and personal messages were also broadcast. In fact the prime role of Radio 2AP was to facilitate communication to the far-flung communities which had no access to telephones or newspapers. Despite the passage of time this role is still being carried out by Radio 2AP to this day.as telephone coverage is still limited and newspapers don't have the immediacy that is required.

Up until 1959 expatriate officers ran the station with some local Samoan trainees. With the formation of the first provisional government on 5 September 1959 in anticipation of independence from New Zealand, Radio 2AP became a government department. It was at this time that the first Samoan director, Mr. Frank Blunt was appointed. In the following year Mr. Jim Moore was appointed as director - a post which he held for 23 years.

As time progressed it became apparent that the broadcasting service was developing into a vital avenue for the preservation and extension of Samoan culture. Samoan history is related to the young in the oral tradition of legends or stories. The medium of radio was an ideal way to keep these stories alive. In a similar vein the development of Samoa's distinctive musical style was encouraged through radio. The requirement of announcers to be fluent and skilled in the Samoan language has assisted in maintaining a high standard of speech within the community.

In 1962 the transmitter at Afiamalu was upgraded to a 10kW AWA transmitter on a frequency of 1404kHz. This transmitter remained in service till 1988.

The installation of the new transmitter coincided with Western Samoa becoming a fully independent state - the first Pacific country to do so. In its role as national broadcaster the celebrations were covered by Radio 2AP non-stop for five days and nights. This tradition of broadcasting events of national significance has continued to this day.

To comply with the standing orders of the Legislative Assembly of Western Samoa which requires parliamentary sessions to be broadcast in both Samoan and English a second transmitter was installed at Afiamalu in 1967. The transmitter was a 3kW Wilkinson transmitter on a frequency of 1062kHz. In order to make use of the spare capacity of this transmitter during non-sitting periods an English language channel was inaugurated. The purpose of this second channel was to service the expatriate community and to provide an alternative programme format to the main Samoan channel which was required to broadcast personal and government messages at night.

The year of 1981 saw the culmination of a bilateral aid project with the New Zealand Government and BCNZ (Broadcasting Commission of New Zealand) to improve the coverage area of Radio 2AP. Three low powered transmitter sites were installed to improve the reception in areas which hither to had difficulty in receiving transmissions from Afiamalu. The sites were located at Natoi'i (540kHz), Taga (1395kHz) and Asau (1251kHz). The transmitters used were Harris MW-1A

solid state units and operated at a power output of 1kW.

In 1983 Radio 2AP was host broadcaster for the South Pacific Games held at Western Samoa's capital, Apia. Radio 2AP provided switching facilities for Pacific Island broadcasters from the games' venues. It was also in 1983 that Tupai Joe Kuka Brown was appointed as director.

After 26 years of service the 10kW AWA transmitter at Afiamalu was replaced by a 2.5kW Nautel Ampfet transmitter in 1988. It was at this time that it became apparent that the task of maintaining the many remotely located transmitters, some of which were powered by aging diesel generators,was beyond the financial and human resources of Radio 2AP. Bearing in mind the essential requirement of fail-safe communication in times of cyclones Radio 2AP director Tupai Brown decided to co-locate the transmitter site with its broadcast studios in Apia. The advantages of having the transmitter close by for maintenance and at sea level to enhance coverage were the prime reasons for this move.

In 1990 a new transmitting facility was opened at the studios of Radio 2AP. Three Harris DX 10 transmitters were provided by the Australian Government to operate both the Samoan and English language services. Two of the transmitters operate on 540kHz in an on-air/standby configuration (Samoan language Service) while the third transmitter operates on 747kHz (English language service). All of the Western Samoa island group is serviced from this central location and it is possible for the people of the Tokelau Islands, some three hundred miles away to monitor our transmissions.

The role of Radio 2AP in 1994 is much the same as it was in 1947. We still are a vital communication tool for the country despite the improvement of other forms of communication. Sure, we now use state of the art digitally modulated transmitters and our outside broadcasts are carried by UHF radio links instead of telephone lines but our task is essentially the same. Radio 2AP in 1994 is still very much a community based radio station serving the people of Western Samoa.

What does the future hold? The introduction of a privately owned FM service in 1989 and the introduction of television has altered the landscape somewhat. Competition between the various mediums has had positive results in that each organization seeks to provide the best service to attract listeners and advertising revenue. Radio 2AP's natural advantage of having national coverage will be eroded as the other mediums increase their coverage area. But it is our belief that if we keep uppermost in our minds the wishes of the listeners Radio 2AP will enter the 21st century as strong and robust as it always has been.

Based on the recollections of Tupa'i Kuka Joe Brown.

Written by William Tibben, 1994.

APPENDIX 1.3

Facsimile Detailing Author's Correspondence with Radio Station Concerning a Transmitter Fault.

Fax Transmission

To: [redacted]
Fax: [redacted]
Ph: [redacted]

From: William Tibben
Fax: Int'l 61 [redacted]
Ph: Int'l 61 [redacted]

Date: 6 March 1997.

Page 1 of 1

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Dear [redacted]

Good morning. I hope that you are fit and healthy!

[redacted]

With regards to our conversation about the voltage regulator IC UC 3834 - I have been looking back of some of the notes I made when I was at 2AP but nowhere can I find the pin number for the output of the voltage regulator. I know its not pin 1, 2, 3, 6, 7, 8, 9 or 10. But maybe its not important.

[redacted] described the fault you had (Envelope Error light is Red) and he told me the IC on the DC regulator board was getting hot. We had a fault like that a few years ago on Tx 3 (a cyclone was heading towards Samoa, it was Sunday so Ch 1 had not come on air yet, I came out of church and there was Taulima and Foa - they told me Ch 2 was off) On that occasion it was the IC in the "Modulated B" supply which is found on the DC regulator board. It is a funny circuit because it has the audio signal driving the input of voltage regulator IC 3834. The D.C. output is fed to the RF amps and adjusts the timing of when the RF amps are switched On and Off. (I can't remember why this is done)

Anyway, having thought about it what I suggested is not that important. Go ahead and put the IC in (make sure its the right way around - pin1 next to the dot on the circuit board) and check to see whether its getting hot once you have put the board back and checked all the plugs are in.

My advice about checking for a short on the caps which are connected to the output pin of the regulator is based on the idea that is easier to check this with the IC out. If the IC is still getting hot you most probably have a shorted cap on the output line. Check the resistance from the output of the IC to ground (with the power off) - it should be greater than 15 ohms. In this case you can fax me a copy of the circuit and I can refresh my memory.

Kind regards,

William Tibben.

Fax: +[redacted] Ph: [redacted]

Appendix 2

Research Data.

TIMETABLE OF EVENTS

Day 1 - Saturday	Day 2 - Sunday	Day 3 - Monday	Day 4 - Tuesday
• Arrival • Trip from Airport to Radio Station. • Introduction to Chief Engineer's Family.	• Interview with Chief Engineer. • Trip to radio station for evening broadcast of church service.	• Participant Observation at Radio Station. • Interview with Programme Director.	• Interview with Chief Engineer. • Investigate Envelope Error Fault with Technician • Interview with Video Officer, University of the South Pacific (USP).

Day 5 - Wednesday	Day 6 - Thursday	Day 7 - Friday	Day 8 - Saturday
• Interview with Manager of Private FM Station	• Examine printed information sources • Interview with Tarja Virtanen, UNESCO	• Visit workshops of telecommunication company • Performed tape recorder alignment with Trainee	• Review of field notes.

Day 9 - Sunday	Day 10 - Monday	Day 11 - Tuesday	Day 12 - Wednesday
• Investigated Aerial Change-over Switch with Chief Engineer.	• Interview with Senior Operator • Interview with Technician • Interview with Trainee • Interview with First Assistant Secretary, Australian High Commission.	• Visit to Media Centre, National University of Samoa (NUS) • Swapped Audio Signal Processors with Chief Engineer.	• Lunch with Church Pastor • Interview with Manager.

Day 1 - Saturday.

Trip from Airport to Radio Station

- Initial impressions of the trip from the airport to the radio station, 2AP, are as follows. The radio in the vehicle was on. I recognised the announcer's voice and commented how clear I thought the sound was. This was in context of the Chief Engineer listening to the radio as we left - he commented that he is still expected to keep an ear out to the radio even though the radio station has not provided him with a vehicle to attend to out-of-hours faults.

- There was a considerable amount of activity in the villages we past through. Some church and sporting clubs had barbeques under way and were selling food for fund raising. As the road follows the coast, I could see kids swimming in the lagoon. People were busy preparing for the Sunday. Cutting grass with bush knives, travelling to and from the market. The preparations are for lunch after church when people return home to have a big Sunday lunch (to'onai)

- On the way from the airport to 2AP the Chief Engineer related to me the main items of interest. These were the Senior Operator's trip to Japan for an Audio Engineering Course and the technician's trip to Malaysia for a tape recorder alignment course. The Senior Operator's and the Technician's training took priority over the Chief Engineer going on training courses, as it had been so long that either had been on training (the Chief Engineer was the most recent, when he returned from Australia four years previously)

"I like to give these guys the opportunity to learn more, that's why I sent them"

Comment:
Training courses are seen as vitally important. The comments about training should be viewed within the context of the limited opportunities staff had in attending training courses under the former manager. There is considerable pent-up demand for training.

- The Chief Engineer regrets that he moved straight into the position of chief engineer as he feels he has missed out on the experience of working at the bench with a multimeter repairing equipment.

"I really miss not working on the bench with a multimeter and getting to really know the equipment".

Comment:
In terms of discovering how the Chief Engineer perceives his role within the radio station, this comment suggests it lies with problem solving. The comments are reminiscent of Orr's (1996) photocopier technicians who see their role as being mainly concerned with dealing with machine faults.

- The Chief Engineer told me about their recent success in providing live coverage of the Pacific Mini Games in Pago Pago, American Samoa. He set up the receiver aerial by attaching the pump-up mast to the disused tank stand next to the studio building. The transmitter aerial was established on the "Rainmaker" mountain in Pago. This site was a repeater site as the programme was beamed up from the site of the games. By all accounts, it was a busy time but the reliability of the link contributed significantly to the positive response the radio station got from the local public. The Chief Engineer has left the receiver aerial attached to the tank stand as he is currently trying to pick up a signal direct from Savai'i. Every weekday, an announcer in Savai'i contributes about three hours of programming. A studio has been set up as well as a radio frequency link. The link has been troublesome as interruptions to power at the repeater site on Mt. Fiamoe mean that programme can be lost with no warning at all. Hence, the Chief Engineer's efforts to get a direct link from Savai'i so as to remove the weak link of Mt. Fiamoe.

Comment:
Outside broadcasts represent an important element of the radio station's service to the community. Later conversations with the technician reveal that the quality of the coverage compared favourably with the local Pago stations. The ability of the engineers to mount a live broadcast from most places around both islands is the basis for considerable advantage over the rival FM station. See interview with manager of rival FM station.

- On arriving at the radio station I said hello to the announcer who was on duty. I noticed that the workshop in which the Technician, the Senior Operator and the Trainee work appeared cluttered by the amount of equipment which was stored in shelves and on various tables. The office in which the Chief Engineer works is also the central equipment area so he is able to monitor broadcasts while working. The book shelves contained equipment manuals, college texts, broadcasting magazines and journals. The room adjoining the Chief Engineer's office is used to store back up

equipment and spare parts and other valuable items. Adequate storage space in the adjoining store room appeared to be also in short supply.

- The studio building is a weatherboard building and looks like for all intents and purposes a residence. The building is shared with the television service.

- I commented on the new equipment which had been recently purchased for the studio. I was particularly interested in the cassette player with the double deck. The Chief Engineer said that this new equipment had been purchased through a local business and the idea of a double deck machine came from the proprietor of this firm. He said he has lately channelled a few orders through this business because he found it too difficult to arrange for the supply of equipment direct from overseas. This he claimed was a factor of the bureaucracy of the central purchasing authority, the agency he has to channel his orders through.

- I also noted that the digital audio computer in the studio was not working. The announcer told me that the computer had been out of service for a few months. The announcers have gone back to playing ads from cartridges.

Comment: This early discussion of the difficulties of procuring equipment became a theme of the visit where the difficulties of arranging the purchase of equipment was a source of frustration for the Chief Engineer

- We walked over to the transmitting building which is situated across the road from the radio studio building. The transmitter building is made from concrete block and is elevated from the ground by 2 metres. This is because of its proximity to the sea and the likelihood of sea flooding during cyclones. The building houses an emergency power generator in one half of the building and three 10 kW transmitters in the other half of the building. The 2 areas are separated by a concrete block wall.

- Two transmitters, Tx 1 and Tx 2, are tuned to the same frequency and carry the main (channel 1) programme. The third transmitter (Tx 3), is tuned to a different frequency and carries the school broadcasts for one hour every morning, English programming during the evening and all day Sunday and the English translation to parliament, when it is sitting.

- Transmitter 2 was indicating a fault called Envelope Error. The Chief Engineer identified this fault as one fault he wanted me to "...go over..." with him. He told me

that the transmitter would not switch on and that he had replaced an IC on the Controller Board which was getting hot. After ordering a new IC from the transmitter distributors in Australia, he found out that the new IC was also getting hot. I was surprised to see that this fault was still a problem as I had been contacted seven months previously by the technician to assist him with the problem (as the chief engineer was away. I replied (See Appendix 1.3) and requested copies of the circuit be faxed should further assistance be required.

Comment:
This fault was the subject of a telephone conversation I had had with the technician seven months previously while the Chief Engineer was away. The fax reveals that I was mistaken about the board under question but the suggestion that the problem could lie with a shorted capacitor was subsequently found to be correct (see Day 4).

- I was told that transmitter 3 had suffered a major fault three months previously. The Chief Engineer related the story of the repair he performed on this transmitter. There was no power getting to the RF Drive circuits. This was a tricky problem because even though zero ohms was measured across the fuse it turned out the fuse was in fact open circuited. This discovery was made after he had worked throughout the night. The reason he needed to work through the night was because the transmitter was required for the broadcast of Parliament. As there is a requirement for two frequencies to be in operation to carry both the proceedings in Samoan along with an English translation, the Chief Engineer was under a great deal of pressure to solve this problem. His investigations included checking associated circuitry, as detailed in the trouble shooting section of the equipment manual (Harris, 1994, pp. 6/7-6/8) As he related to me, when he discovered that the problem was a blown fuse just hours before parliament was due to begin and then confirming that the transmitter worked he immediately went home to catch up on his sleep.

  "... it was the fuse all the time. When I put a new one in it all started to work. I walked to the office, told...[the manager]..., jumped in my car and went home to sleep...".

Comment:
In this particular problem, the power supply feeding the RF drive circuits was cut off by a blown fuse. The Chief Engineer had traced the problem to the power supply. However, resistance checks around the circuit revealed a measurement of zero ohms across the fuse. He was probably measuring the charging of the large capacitors connected to the fuse and not the fuse itself. This reveals the difficulty an engineer has in performing fault finding

with the aid of an ohm meter looking at resistance measurements. The use of an ohm meter in this circumstance is necessary as measuring voltage in this part of the transmitter is extremely hazardous because the power supply is rated at 250 Vdc at many amps. It is usually very difficult to predict the resistance of particular paths in a multi path circuit. Generally, this problem can be overcome by removing components before testing. The Chief Engineer did not do this and placed too much reliance on the meter to reveal unambiguously the nature of the circuit's performance.

An indication of the importance of parliamentary broadcasts is seen in the effort expended to get the transmitter working on time. Before this, the school broadcasts and the evening English programming was affected by the problem in Tx 3 but this did not seem to provide sufficient impetus to work throughout the night.

- After visiting the radio station we returned to the Chief Engineer's home where I was also staying. After being introduced to his parents and the rest of the family I discussed the purpose of my visit with the Chief Engineer's brother, Harry.

- Harry is employed by the local telecommunications company. He spent two years in the Solomon Islands to gain a technician's certificate. He found the course most useful for his current job. He expressed the belief that theory is essential in developing practice. He sees fault finding as a methodical process of stepping his way towards the goal of 1) knowledge about the problem and 2) solving the problem. His comments to me:

  "...once you know theory, you can practice it...".

- Harry repairs televisions and radios in his spare time. He has difficulty in procuring spare parts. He has friends in the satellite section who have contacts in New Zealand who are able to get parts but notes they seem to be expensive. Harry manages to fix appliances without circuits through a process of checking for dry solder joints, damaged components and spot checking of components with a meter.

Comment:
The Chief Engineer's focus on fault finding and Harry's faith in the primacy of theory represent significant indicators that many of the beliefs and views one could reasonably associate with an engineering ethos have been adopted by these Samoan engineers.

The context in which this conversation took place, the family home, was significant for two reasons. The normal setting of the Samoan (fale) initially appeared at odds with the

subject of conversations - the maintenance of modern technological artefacts. This was made more poignant by the lecture I received on the primacy of theory over practice. This raises doubts about the extent to which Enos draws distinctions between local cultural practices and abilities to achieve technical excellence. The concepts of engineering appeared to have been successfully grounded in these two practitioners. The fact is that the non-European setting appeared to be of little consequence to the maintenance of commonly held views of engineering.

The second factor which was of importance is the enormous degree of pride that the parents derive from both the Chief Engineer's and Harry's qualifications and the jobs they currently hold.

Day 2 - Sunday.

- Sunday afternoon presented an opportunity to discuss a number of issues in greater depth. Conversations took place at both the Chief Engineer's home and, as the Chief Engineer was required to attend to the broadcast of the evening church service, at the radio station.

- The Chief Engineer's experience with obtaining spare parts and new equipment from overseas is one characterised by difficulty which in turn has a negative effect on maintenance activities. On asking to explain this further, he said the time between first seeking quotes and final delivery of parts is a minimum of 6 weeks and often is much longer. For example, the purchase of high capacity fuses for the transmitter was difficult as there are a variety of sizes as well as fixing arrangements (screwed or unscrewed lugs or no lugs at all). Establishing the nature of the fuse required a considerable degree of faxes back and forth with the supplier. He says it is easier to channel orders for new equipment through a local business.

- The Chief Engineer explained that the procedure the central purchasing authority dictates for getting goods from overseas - two forms requisition (TY 13) and an authority to pay (TY 1)invoice needs to be processed for payment before goods are delivered (which often is time consuming 2-3 weeks). On arrival goods need to clear customs by payment of duty (50% duty, 45% excise 10% VAT)

- In comparison, the procedure of getting goods from a local supplier is considerably simpler. A local order is raised and an invoice is presented when goods arrive and duty and VAT paid. Despite the procedure being less difficult, getting payment cleared from Treasury can still be delayed considerably.

- There is reason to believe that the difficulties associated with ensuring payment is made to suppliers in a timely fashion dissuades the Chief Engineer from making contact with them. His comment to me:

  "I hate calling up overseas suppliers to ask for prices when I can't promise them they will be paid quickly"

- The issue of late/slow payment for goods in relation to the local supplier is overcome to some extent through the Chief Engineer's personal relationship with the proprietor. He has been willing to process further orders and perform work for the radio station (such as changing the globes on the mast). The Chief Engineer says that the relationship is under some strain however with reminders about non payment given in most communication between the two. The Chief Engineer fears that ultimately this problem will influence the proprietor to reassess the suitability of 2AP as a viable business proposition.

Comment:
The issue of governance over the commercial dealings of government departments is reflected in the above transcript. While the measures are put there to ensure all dealings are proper there is little doubt that delays incurred are a significant impediment to the timely resolution of problems in the radio station. This is particularly true for essential items of equipment or spare parts, the absence of which is reflected in less than optimal operation of equipment or organisation (e.g. the absence of headphones in the on-air studio).

The decision by the Chief Engineer to direct the order for new equipment to a local business as opposed to identifying an overseas distributors from which these items could be directly purchased, appears as a strategy aimed at overcoming the complexities of international commercial dealings between the central purchasing authority and overseas companies. In contrast, the relationship the Chief Engineer enjoys with the local supplier is a friendly one in which the suppler, with established commercial relationships with overseas suppliers, acts as an intermediary thereby reducing the risk of both the central purchasing authority and the overseas supplier.

- The need for new equipment in the studio was generated by a initiative in early 1995 to establish a remote studio at Salelologa on the neighbouring island of Savai'i. The move was a popular one as the 6 hours of programming which is linked from Savai'i and broadcast has proved popular with the public and the Minister of Broadcasting (as his constituency is quite close to where the studio is located). An announcer who has family on Savai'i was sent across to look after the studio and has really excelled as a result of this new opportunity. So much so, that his popularity is currently rivalling another announcer who is well known for his humorous and lively broadcasts.

- This initiative came at some cost to the operations at the main studio. Equipment had to be gathered from spare equipment and equipment in use in the studio making the announcers life more difficult as well as leaving the engineers without working back-up equipment. The promise of extra funding for the replacement of this equipment was not realised for another 21 months when the replacement equipment finally arrived in March 1997.

- The reasons for the delay in procuring the replacement equipment appear related to both the failure to have this new expenditure incorporated in the budget estimates of the following year, effectively delaying the allocation of funds for 12 months, and the difficulties of procuring equipment. As noted previously, the procurement of equipment involves a complex and frustratingly slow process of placing requests for purchases through a central government purchasing authority.

Comment:
In summary, the impetus for the new studio can be clearly associated with a need to fill a gap in the radio station's programming - that is, programming which aims to satisfy rural listeners, particularly those on the neighbouring island of Savai'i. The fact that the constituents of the Minister of Broadcasting form a part of this target groups represents a smart political initiative. The alternative strategy of waiting until funding was allocated for the procurement of new equipment for this studio would have ensured that the concerns of both announcers and engineers were met but would have arguably introduced considerable delays in the realisation of this new initiative. It is interesting to note that, in responding to this demand, the complexity of the task for the Chief Engineer was more a factor of the constraints placed on him by the organisation rather than his lack of technical knowledge. The initial coercion used to sway him in agreeing to the relocation of existing facilities was based on the needs of rural listeners but when it came to providing him with the means to ensure the viability of these new arrangements, the organisation effectively left him short changed in equipment for a period of 18 months.

- The Chief Engineer told me that the radio station has been off air through technical failures only twice in the preceding three years. He admits that the feeling of being totally responsible for the technical system was daunting and often he feels that the task is a lonely one. He says that he often has people on the street inquiring from him details about the course of events at the radio station. He is basically on the job all the time when out in public or at home monitoring the broadcasts of 2AP.

Comment:
The Chief Engineer sees that maintaining transmission is of considerable consequence. While this reflects on his technical ability as the Chief Engineer it is also a measure to him of the social consequence of his position as head of the technical facilities at 2AP. The occurrence of only two major breakdowns in as many years suggests the transmitter is quite stable and ironically doesn't provide many opportunities for learning for the Chief Engineer.

- The Chief Engineer also told me that the central authority responsible for personnel matters of government, had embarked on a plan to reduce staff and increase wages. The Chief Engineer has been waiting for some time to have a chief technical officer appointed but was having difficulty in that he was swimming against the tide of conventional wisdom. Interviews for the job were being held the following Monday.

- His need for a chief technical officer relates to his experience where the bulk of the responsibility of keeping the station on air has fallen on his shoulders. He mentioned that the benefit of a chief technical officer was that he could discuss technical problems - something he cannot effectively do with others in his technical section because they lack the necessary experience. His comments to me were

  "I can't rely on those other guys to help me - I have no one to discuss difficult faults with".

- In addition to this, the presence of a chief technical officer will allow him to move around more freely than at present. He related the following example. Some time ago he went to Savai'i by ferry to supervise an outside broadcast at Salelologa. On arrival at Salelologa 2-3 hours after his departure from the station) he was told 2AP was off the air and was sent back by the director by the same ferry as the Senior Operator couldn't fix the problem (another 2 hours - this time he didn't have to queue to get on the ferry).

- Another instance was when he was at home on sick leave. He had a boil under his arm and found it painful to move about. He received a call from the manager asking him to come in as the station was off the air. Both the technician and the senior operator had investigated the problem but could not find the cause. The transmitters were apparently OK and programme was leaving the studio. The Chief Engineer went in to work. On walking into the transmitter building he noticed that the amplifiers feeding program to the transmitter had been turned off. He switched the amplifiers back on and the problem was solved. It turned out that the trainee had been recording maintenance data and had inadvertently switched the amplifiers off instead of the speaker he was using to monitor the broadcast.

- In the light of the time it has taken for the manager and the central personnel authority to respond to his request for a CTO, the Chief Engineer feels that his superiors do not have enough faith in his abilities. His assessment is:

  "I feel like there is no trust there"

- The skills of his support staff also came up during conversation. On one occasion during the repair of the transmitter the circuit breaker was inadvertently switched on by a staff member before the person proceeded to begin doing resistance meter checks on a circuit which had 415V applied (he thought he had switched the power off). The incident was particularly important as the consequences of this mistakes, if the Chief Engineer had not realised, could have been fatal.

- Relatedly, the Chief Engineer told me that he discusses technical problems with his brother and cousin, who both work for the telecommunications company, but within the context of the previous remarks, this communication appears as having only limited benefit. The nature of the systems are quite different - the brother and cousin work on low powered radio telephones. Radio telephones represent but a small part of the Chief Engineer's responsibilities.

Comment:
The weight of the technical performance of the radio station fall totally on the Chief Engineer's shoulders and raises questions about the wisdom of indiscriminately pursuing down sizing policies in situations where staff numbers are already low. There is little opportunity for using a knowledgeable other person as a sounding board and using new ideas by which to arrive at a new understanding of the problem. The Chief Engineer is alone and is the only one who is capable of getting the station back on air and as a result his presence in the precincts of the station is required always. The incident with the

breaker reflects the danger when tacit knowledge is absent. The breaker provides tactile feedback indicating whether the breaker is being turned on or off - it is more difficult to switch the breaker on than off. The fact that the support staff member had not learnt the difference between turning a breaker on and off signifies a lack of engagement with a basic electrical device which is designed to prevent serious accidents from happening.

- The Chief Engineer mentioned that the new Polytechnic is experiencing a high failure rate. There is currently a push to have the entrance standards raised from a University Entrance (UE) to University Preparatory Year (UPY). There are quite a few people who complete the UPY but do not get the opportunity to go to university so the only option is the Polytechnic. The Chief Engineer has done some part time teaching at the Polytechnic and he notices the difference in quality of students between UE and UPY. Of some significance is the difficulty he had in obtaining time off from work. Naturally, the manager is concerned with having the Chief Engineer on station in case of equipment faults so was somewhat reluctant to give him leave to carry out teaching. An arrangement was struck in which he would not be docked for the time he undertook teaching as long as he was prepared to leave his teaching the moment a technical problem arose at the radio station.

Comment:
The availability of students for the Polytechnic is not a problem. Its interesting to note that people with adequate grounding for university have no choice but to go to the Polytechnic which indicates a better quality student. It is not known whether these better quality students are finally transformed into better quality trade people or para professionals. The establishment of a Polytechnic is noteworthy as it represents increasing deployment of institutions in country - this one funded by the Japanese government within the last 4 years. The new campus for the National University of Samoa (NUS) was also funded by Japanese aid.

The difficulty associated with gaining permission to teach at the Polytechnic reflects the shortage of skilled labour - while it makes sense for the Chief Engineer to be used as an teacher in educating more local people, the practical need to maintain transmission at the radio station is arguably a more immediate concern for the manager. This appears to reflect the problem that Enos (1991, pp. 170-171) identifies - whether it is best to direct investment to education or to maintaining and improving capital infrastructure. In this instance, it appears that a compromise has been worked out to the satisfaction of involved parties.

- The purpose of our visit to the radio station in the early evening was to confirm that the recording for the Sunday night church service was ready to go. In the past, this service was broadcast live but with the advent of television, this practice was discontinued. This was because the television station had no way of broadcasting the service live and as the church committee overseeing the organisation of these services was keen to see them on television. This could only be done by pre-recording and requested that these services be recorded in the afternoon. This has been a disappointment to the engineers as they feel that their abilities are being limited by the television station.

- Despite the increasing penetration of television in the outlying villages, many still listen to the service on the radio. Perceptions over the technical abilities of both the radio station and the television station are dependent on the punctual and uninterrupted broadcast of the Sunday evening church service. Hence, the need to travel into the station to ensure the broadcast goes to air without any problems.

Day 3 - Monday.

Radio Station 2AP

- The radio station broadcasts the following hours. The main programme channel, channel 1, is broadcast from 6.00 am to 11.00 pm Monday to Saturday and 6.00 am to 10 pm Sunday. The programming is bilingual (Samoan and English) from 6.00 am to 6.00 pm from when broadcasts are in Samoan. Programming on Sunday is wholly in Samoan.

  The second frequency (channel) carries English programming. This begins at 4.00 pm in the afternoon and goes through to 11.00 pm Monday to Saturday. On Sunday, broadcasts begin at 8.00 am and continue to 10.00 pm. Every weekday morning during school term, this channel carries a one hour programme from the Education Department between 8.30 am to 9.30 am.

  When Parliament is sitting, broadcast times are determined by parliament. In this event, channel 1 broadcasts are wholly in Samoan and the channel 2 programming is in English, including an English translation of the proceedings.

- Information broadcast by the radio station includes: Local and overseas news, weather reports, commercials; current affairs programming including rural, health religion, women affairs, youth, traditional story telling; notices from government, public and private organisations (alterations to shipping and airline schedules); personal notices such as for sale, lost and found; job advertisements.

- Radio Australia is translated every morning and evening into the vernacular for broadcast at lunchtime and evening, Monday - Saturday.

- The radio station holds a variety of archival material including official speeches recorded at the time of independence.

- Current staff numbers 22 people.
  Technical - 4; Programs - 8; Advertising - 4; Management (Manager, Administrative Assistant and Adviser on cultural affairs) - 3; Ancillary staff (driver, tea attendant and night watchman) - 3.

- Routine maintenance of studios (head cleaning) is carried out every morning.

Comment:
Routine studio maintenance is evidence of knowledge which has become in grained into the daily routines of the engineers. Even though routine maintenance is carried out by junior members of staff, it represents an important strategy in maintaining on-air sound quality.

- The lack of telephone lines is causing some tension between the telecommunications company and 2AP. The technician has received a hostile reception from the telecommunications company on two occasions already. The Chief Engineer subsequently confirmed that relations with the telecommunications company had been strained and is not sure why - possibly the increasing use of Radio Frequency link equipment for outside broadcasts and more recently, the fibre optic line from Parliament House.

- Later the Chief Engineer commented that relationships with senior staff at the telecommunications company are quite good. For example, the Chief Engineer has a good relationship with the Comptroller of the telecommunications company

  "if I have any problems I call..[the Comptroller] ...up and he usually sorts it out for me"

Comment:
It is interesting that the two organisations which are most closely aligned in providing public communication services exhibit a significant degree of competitive behaviour. The existence of good communication between the managers of telecommunications company and the Chief Engineer enables most problems to be resolved quickly but the relationship is somewhat lopsided - the radio station's need of the telecommunications company is more immediate than the reverse. One factor the radio station has in its favour is that when a line used for broadcast goes faulty, the public nature of the failure suggests that it may be potentially embarrassing for the telecommunications company.

- The technician asked me to explain the lists of tag block designations used to record the interconnections between various pieces of equipment in the studio building. As I was the person who devised this list I was disappointed to see technician was having trouble understanding the basic arrangement of information.

Comment:
The mention of the tag block has personal significance for me as I had originally composed the tag block diagram. It was clear that the tabular arrangement I had devised was not particularly easy for the technician to follow and despite my best intentions it seemed that I had neglected to include the information the technician required to understand the lists. My visit provided him with opportunity to clarify the meaning of these lists

Interview with Program Director.

- The Program Director is currently attending a course on Trade Related Intellectual Property (TRIPS) sponsored by AusAID. The issue is a potentially difficult one for the implications this holds for the broadcast of overseas produced music. In particular, as some local musicians have been using popular melodies from western tunes and have overlaid these with lyrics in the vernacular, he is concerned that this practice will lead them into trouble in the future. The Program Director has attempted to stop the broadcast of such songs but admits it is difficult because these songs are popular with public.

- The Program Director is undertaking a Public Service management degree with Massey University by correspondence in NZ. The course attempts to relate theoretical aspects to the environments in which the students work in by completing case study assignments of particular. The Program Director sees moves towards

greater accountability in the Public Service as the major trend. Reforms sponsored by such bodies as the World Bank are not always directly applicable so an attempt is being made to make changes which "...conform to the general spirit of reforms but softens the impact to people..." of the more controversial aspects. The Program Director does not have much time for those who argue that culture represents a block to the use of modern technology. Rather, he sees this as an excuse and says these people need to get off their "butt".

Comment:
The Program Director's comments about culture reflect a significant degree of impatience with the idea that culture is a barrier to technological development. The following comments about World Bank reforms suggest that there is an underlying faith in the cultural processes of Samoa to mould outcomes which are both responsive to the requirements of technology and maintain the core values of Samoan culture.

Day 4 - Tuesday.

- The Chief Engineer developed a number of friendships with fellow Australian students while studying there. So much so, that soon after his return to Samoa, he was asked by one friend to be his best man at this person's wedding in Australia. He was unable to attend. This person had become the manager of a retail electronic components store. Since then, the Chief Engineer has lost contact with this person as well as with his other student friends.

- In the year prior, the Chief Engineer travelled to the headquarters of the regional broadcasting organisation called PIBA (the Pacific Island Broadcasting Association) for the annual Engineering Committee meeting. He described the meeting as enjoyable and as a good place for discussing problems - many of which they shared in common. The meeting produced an unexpected opportunity for the radio station to dispose of a decommissioned Nautel broadcast transmitter. Another engineer expressed interest in the unit for spare parts and was willing to pay for it was well as freight.

- This idea was subsequently quashed by the manager who viewed the unit as a possible back up transmitter during a cyclone. This idea, the Chief Engineer felt, was

an impractical one and felt offended that this initiative to get rid of this large item of equipment from the workshop was not recognised for the benefits it provided not only to the technical section, but the radio station in that it was able to recoup some money for the unit.

- In between annual meetings, the Chief Engineer says that little contact is maintained between Engineering Committee members. The exception is those who are working on a standing committee.

Comment:
On the basis of his accounts of his experiences while studying in Australia and the photo's he showed me of parties etc he had, the Chief Engineer made a number of friends with fellow students while studying at the TAFE in Queensland.

The Chief Engineer's disappointment over the decision not to sell the old transmitter demonstrates to some degree the need for engineers to be able to exercise some autonomy for there was potential for this transaction to lead to further cooperation between the two radio stations.

My latter attendance at an Engineering Committee meeting confirmed the impression I had gained from the Chief Engineer. There was a lot of discussion during tea breaks and after the meeting among the engineers about challenging faults they had encountered which was accompanied by a certain degree of bravado similar to the "war stories" that Orr (1996) refers to in his study of photocopier technicians. On asking these engineers whether they maintained contact between Engineering Committee meetings the general response was in the negative except for contact between members on standing committees. It seems difficult to extend these active communication relationships into the intervening periods between meetings.

- The problem with the Envelope Error in Tx 2 was investigated. The transmitter would not switch on and one regulator IC on the Controller Board was getting hot. For an Envelope Error Fault, the trouble shooting guide advises that the transmitter will remain functional and the likely cause of the problem are failed RF modules (Harris, 1994, p. 6/11). Hence, there is a contradiction between the fault indication and the information trouble shooting guide in the manual. The Chief Engineer identified another error indicator on the Controller Board, the same board on which the over-heated IC was found. This was which led him to test various components with his finger to determine their temperature.

- I suspected that the fault lay with a low resistance path on the output of the regulator IC. After removing power from the transmitter, we took a resistance measurement from the output of the regulator IC to ground and found that it read 11 ohms. There was some question whether this represented an insufficient resistance to cause the IC to overheat so we decided to compare the reading with transmitter 3 which was off air. This yielded a reading of 30 ohms suggesting that the 11 ohms of transmitter 2 represented a fault. The technicians disconnected associated cabling to the Controller Board but the reading of 11 ohms remained suggesting the fault on the Controller Board. The technician then removed the board and began removing components that I had identified on the circuit diagram. He eventually found one capacitor which was faulty. We then spent about an hour looking for a suitable replacement part. While it was possible to find the correct capacitance value, the physical size of these components provided to be the problem. We eventually compromised on a polyester capacitor which was slightly too big but we reasoned that it was more important to get the transmitter going and order one for later replacement. The capacitor requiring replacement was a common part and available from stores such as Dick Smith in Australia. The problem is that there are no local electronic spare parts shops who carry a sufficient range of components.

- The Chief Engineer says that he has learnt more about fault finding techniques from his own efforts and with the minimal contact he has had with other broadcast engineers than when he was required to undertake fault finding exercises at TAFE. The faults presented to him at TAFE were not like the faults he now encounters in that the faults at TAFE were predictable to some extent as they were related to some aspect of the course he was studying.

Comment:
The decision to compare resistance measurements with Tx 3 is preferable to attempting to calculate from the diagram the expected impedances of the attached components combined.

- A fault with the telephone hybrid has meant that telephone interviews have not taken place for some time. The device is used for recording interviews for use in the news. Only one announcer makes use of this facility live and this is more game styled question and answer rather than for eliciting comment from the public on current issues. This announcer did express displeasure at the broken telephone facility suggesting some tension between him and the Chief Engineer. In reference to an another instance where it took time for the cartridge machine to be repaired he commented to me:

"...He walks around here all puffed up but the cartridge machine is...[broken]...for two weeks...".

- A three step procedure to isolate the fault with the telephone hybrid was undertaken - first to isolate the problem in the hybrid or line or console. As it was discovered the problem lay with the telephone hybrid reference to the manual was made and the cause of the problem was guessed at by determining the components around the "hold-relay" cold be faulty. A spot check by the technician of a transistor and a number of diodes revealed that all but one of these semiconductor components had failed. The capacitors and resistors were found to be OK. The technician replaced these components with spares from the imprest and the unit was then confirmed to be working.

Comment:
I suspect that it is difficult for the engineers to admit that they are having difficulty repairing an equipment fault. The anger of the announcer revealed in his comments reveal that relations can become strained and one wonders if the delay in repairs represent an element of the power play which is occurring between these staff members.

Interview with Video Officer, Media Unit, University of the South Pacific (USP).

- The IRETA project is an institute within USP which is self sustaining by providing fee for service training course to funding bodies. The self sustaining nature of this particular IRETA project - the agricultural research extension - is reflected in the video unit the Video Officer manages. In addition to core activities such as providing media support services in training courses their brief is also to run media training courses as well as offering their services to the wider community (advertisers government bodies, commercial firms etc) He uses Betacam machines which provide an order level of improvement in quality over Super VHS - the common format chosen by the local television corporation. The current edit suite was mostly funded by the proceeds of "outside work". The unit made $150,000 in one year - they charge $300 per add (which is more expensive than the local television station but some businesses are willing to pay this because they are more satisfied with the finished commercial).

- The Video Officer has a productive and positive relationship with an Australian company in Canberra which is a distributor of Sony products. The relationship appears to be a strictly commercial one but the reliable payment record of the Media Unit suggests this assists them in getting speedy attention. The Video Officer has

established a credit account where goods are shipped on order or by verbal order. For example, the Video Officer only has to call for tapes to be delivered and they'll be put on a flight before the overseas purchase order is raised. The Video Officer also sends his equipment for repair at an average cost of WS $2,000 and time interval of 4 weeks.

- The Video Officer showed me the auditorium where he and the Chief Engineer from the radio station recently installed a Public Address System. He was grateful for the Chief Engineer's help as he is qualified in communication studies rather than engineering. The Media Unit and the public radio often combine resources for large outside broadcasts.

Comment:
There is a notable amount of international communication with the supplier in Canberra. As all of the equipment is small enough to feasibly fit into a box and despatched overseas for repair and maintenance, there is little need for a person with engineering qualifications who is able to repair equipment in situ. Another notable feature of the communication between the Media Unit and the equipment supplier in Canberra is that it is underpinned by a viable commercial relationship. For example, the supplier has sufficient trust to despatched goods before payment is made.

Another important observation is the cooperation which exists between the media unit and the public radio station. The relations are friendly and there is a desire on both sides to assist the other in time of need. This cooperation occurs without the direct intervention of either the universities or the public radio's management but it seems that they must be aware of these relationships so, arguably, they extend tacit approval for such cooperation between their organisations.

Day 5 - Wednesday.

Interview with Manager of Private FM Station.

- In 1989, the private FM station was the first radio station that was granted a licence to compete with the public radio station. The equipment was purchased second hand from a university in the United States by the father of the current manager. The private FM is funded by commercials. Being the first FM station in Samoa, many

people initially predicted that the better sound quality and stereo would mean the end of the public radio station. These initial predictions were unfounded.

- Coverage of the FM signal is significantly less than the national broadcaster. The private FM serves the precincts of Apia, the north western area of 'Upolu and the east coast of Savai'i. The station is owned by the current manager's father who initially ran the station but has since become CEO and lets his son do the day-to-day running. The manager's father and the former manager of the public radio were not on friendly terms. Much of this appears to stem from the departmental advice given to government by the former manager of the public radio, not to grant a licensee to the FM station. This left the former manger of the public radio open to accusations of conflict of interest.

- When the government introduced a Value Added Tax (VAT), the FM had also purchased a telephone hybrid, the device which allows telephone calls to be put to air. Many who rang in complained about government policy, particularly the VAT. The FM station has been the means by which Opposition spokes people have been able to publicise their views other than through the daily press.

- The FM manager's connections are biased to the United States. He was educated in Hawaii and spent 5 years at a Hawaiian university undertaking dentistry. Up until recently, he relied on US suppliers to provide his equipment. He appears quite confident in his dealings with people using fax messages and doesn't seem to see his lack of technical qualifications as being an impediment to owning and running a radio station.

- The FM manager does not have a technician on staff. He relies on a technician friends in Pago who also look after the FM station there. When problems arise he contacts his friends in Pago who talk him through the problem and a local computer technician is directed to the fault. But if this is not successful, they fly over from Pago to look at the problem themselves. These technicians are familiar with station having performed much of the initial installation work. The FM manager mentioned that he was keen to talk with the public radio' chief engineer about possibly offering him a job. He thought he would supplement the Chief Engineer's work by getting him to repair televisions and radios.

- The FM manager is concentrating on overcoming his coverage deficiencies in order to compete better with the public radio and the more recent arrival of competitors on the FM band, who have a Christian orientated programme format. Having limited

coverage means that a major source of revenue, the broadcast of family messages cannot be accepted as they cannot guarantee that families in remote areas will be able to monitor such messages. The FM manager has recently purchased a 300W transmitter to boost his coverage.

- The FM manager complained that his advertising revenue was being squeezed by the public radio, which effectively sets the going rates for advertising, and the newly arrived FM stations, who on being granted special concessions for their religious programming have nevertheless started to broadcast advertisements.

Comment:
My initial attempt to speak to the manger of the FM station was met with suspicion. I suspect this has to do with my former association with the public radio.

In a similar vein to the Media Unit at the USP, the FM station manages without employing a qualified engineer. Once again, this appears a factor of good commercial relationships and being comfortable with using technologies such as the telephone and the fax to coordinate the repair of equipment which is small enough to fit into a box. However, some of the FM station's equipment is too large for dispatch and must be fixed in situ when it breaks down. The admission that he wishes to employ the Chief Engineer from the public radio reflects this need for such knowledge. This may also extend to his desire to improve his outside broadcasting capability. While the FM station has managed to procure comparable equipment to undertake outside broadcasts, they seem to lack the experience of doing so. For example, the engineers at the public radio station maintain that the FM has a poor appreciation for the need for aerial height when conducting an outside broadcast.

The rival FM station has difficulty competing with the public radio on a technical level and a commercial level. On a technical level, the mountainous geography is unkind to the frequencies at which he is required to broadcast at as a FM station. In a commercial sense, the FM station is constrained in what it can charge for advertising as the government is able to set rates through the public radio. The recent arrival of gospel FM stations has compounded his problems.

Day 6 - Thursday.

- I spent Thursday morning looking at the printed information the Chief Engineer had on his bookshelves. The purpose of this exercise was to specify what information the engineers had to draw upon and its relevance to their needs.

- There were a range of equipment manuals. Some domestic quality equipment did not have manuals but the majority items of professional equipment had full technical manuals.

- College text books included radio communication theory, aerial design, practical projects in radio communications (an American Radio League text), principles of operation for Compact Disc player and Rotary Digital Audio Tape recorders (R-DATs).

- Semiconductor data books some of which were out of date (1975)

- Journals and magazines including the following titles: Seminar in New Technologies; Radio World; Asia-Pacific Broadcasting Union (ABU) technical review and BBC Engineering Review. The publication Seminar in New Technologies contained papers from an ITU and FES sponsored conference. The subject material was characterised by technical papers on HDTV and Digital Audio broadcasting. To me, these papers seemed less useful in view of the difficulty the radio station and the local television station were experiencing with the PAL standard. Radio World is a free newspaper styled publication with articles about radio stations around the world-occasionally technical articles are written. Sponsored by equipment manufacturers the intention of the magazine is unashamedly commercial. Asia-Pacific Broadcasting is similar to Radio World except its a glossy magazine with articles directed more at latest technological changes. ABU Technical review is directed at station engineers and is concerned with latest standards but once again, dealing with issues at the technological frontier.

Comment:
The radio station seems to have a significant range of reference material. The publications reveal associations the engineers have with other organisations overseas. There is some reason to believe that the information relating to the latest technologies is more of academic interest rather than practical value as there is little impetus to have HDTV or Digital Audio Broadcast introduced in the near future. These magazines reflect issues

which are important in the arenas of the ITU, NAB, ABU and EBU (European Broadcasting Union) but are rarely is raised in conversation among members of the engineering section. When one considers the difficulties of fault finding, there is also a feeling that there is not enough information here. College text books relay basic circuit configurations but often these configurations are modified by designers when integrated in equipment thereby making it difficult to apply directly to equipment faults.. The college text books seem to provide an awareness of generally how circuit configurations are supposed to work but these do not neatly overlay with faults in equipment.

Interview With Tarja Virtanen - UNESCO

- UNESCO is committed to independent and pluralistic media. The Windhoek Declaration was the first agreement of NGO's (non-government organisations) in Africa to support the 3 ideals of:

  free flow of information;
  information exchange is balanced; and
  reinforcing communications capacity to enable better participation.

- All submissions for funding are directed to the IPDC. There are mechanisms for NGO's to make submissions.

- The current UNESCO programme in the Pacific is aimed at computerising news rooms in a number of Pacific Island broadcasting organisations. Tonga already has its system. Papua New Guinea, Solomon Islands and Vanuatu are designated as the next stations to receive the system.

- Tarja outlined the general implementation of the plan which interestingly included an information gathering exercise asking current users of News Room systems to identify strengths and weaknesses of the system. The intention of this contact is to lay the foundations for developing an informal network in which common problems can be explored. The notion of an informal network among users is seen by Tarja as a cost effective way of exchanging information.

- Networks have always been considered quite important by UNESCO and have always been promoted by UNESCO. UNESCO sponsors a number of university chairs for the development of centres of excellence. ORBICOM is a Canadian based centre for News Editors information exchange. Also an email network of NGO's monitoring abuses in media freedom. Currently joining the Journalist Training

Institute UNESCO's role is to establish a network, facilitate communications and then stand back. UNESCO sees itself as a clearing house for information.

- Informal networks are seen as a cost-effective way of transferring information and knowledge. It is hoped that it has a multiplier effect through it is difficult to measure outcomes. It is anticipated that the networks would be conducted by telephone and fax. Internet (email) is considered troublesome as it is difficult to get access to lines.

- Tarja also mentioned the high costs of telecommunications as being an impediment to greater use of information technologies.

- Tarja also expressed concern at the tenuous nature of technical support in through the broadcasters of the Pacific region which was often reliant on one person.

Day 7 - Friday.

- I visited the Chief Engineer's brother, Harry, and his cousin Jack, at the telecommunication company workshops. Their job is to repair the radio telephone systems they have dotted around the two islands of 'Upolu and Savai'i. The nature of their work involves identifying faulty boards and replacing them with a spare board. The faulty boards are then despatched to a company in New Zealand who then sends back another working spare. Their experience is informative because they reveal that board swapping can be far from straight forward. This is because it is often difficult to determine which board the fault lies on or even if the fault is on the board or part of the motherboard or another system inducing errors in the suspected unit.

- One such example was related to me by Jack. They were having trouble diagnosing a particular fault in a site on Savai'i. Having taken all the spare boards with him, he discovered that he was not able to fix the problem with the boards he had. At first he wondered if one of the spare boards had a fault in it which had not been diagnosed. Then his attention turned to a board for which they had no spare (the reason why they had no spare is not clear except that, on the basis of the following commentary, it was considered unlikely to fail). On studying the circuits he felt certain that the fault lay on this later board and requested from his supervisor that a board be despatched from the company in New Zealand.

- The discussion which ensued between the supervisor and the company representative in New Zealand determined that this board could not be at fault and suggested he undertake a course of action which Jack had already tried and found to be unfruitful. In a subsequent conversation, the representative felt sure that Jack was not correctly performing the procedure and on agreement from Jack's supervisor, decided to fly to Samoa to fix the fault himself. When the company representative inspected the unit, he came to same conclusion as Jack and replaced the board Jack had suspected and the unit started performing correctly again.

- Jack was frustrated at the lack of trust and recognition, particularly from his supervisor.

Comment: The story speaks for itself in this engineer found that he was not fully trusted by his superiors.

- Later in the afternoon, I performed an alignment on the tape recorder with the trainee. I noticed earlier that it had poor sound quality and decided to see if there was a fault or it just required alignment.

- Measure SNR was 35 dB below reference level. Cleaned and demagnetised the heads and adjusted the azimuth. Found that the electronic alignment was quite a way out of adjustment. After alignment, SNR was 50 dB and flat from 30 Hz - 15 kHz, ± 2 dB.

Day 9 - Sunday.

Evening

- In the evening the Chief Engineer and I went to the station after station shut down to look at a problem with the Aerial Change-over Switch between Tx 1 and Tx 2. The problem was that when Tx 2 was selected for transmission it would not stay connected to the aerial - the computer would override the selection and put Tx 1 back on-air. From previous experience (see following for account of this experience), it sounded like the aerial change-over switch had worked itself loose through operation. When the Chief Engineer demonstrated the problem I noticed that the switch was not

arcing as is generally the case when the switch is out of adjustment. We took the cover off the switch and confirmed that the aerial changeover switch was 'rock solid'. Working from my previous experience with the transmitter we decided to look at the indication lights on the monitoring circuits. After a few tries it was noticed that there was no modulation on Tx 2's output even though the indicators said that there was a modulating signal going into the transmitter. (This condition is recognised by the computer as a failed transmitter and automatically puts the alternative transmitter back on air). We traced the audio signal to the transmitter and found that the screws clamping the audio wires into the transmitter audio input tag block were loose. Ultimately a very simple problem who's diagnosis was complicated by the computer's intervention.

- The Chief Engineer told me a story about another instance in which the computerised switching system had contributed to the failure of the contacts on the aerial switch. The contacts failed because of arcing. The manufacturer in Australia claimed that the engineers had contributed to the failure by excessive use and had not taken preventative measures when the arcing become noticeable, suggesting they had purposely continued using the switch despite the obvious symptoms (both light and sound) of arcing. Rather, the computer, when attempting to switch to the second transmitter, would do so in lots of three attempts. As it turned out, the switch had worked its way out of adjustment and every attempt resulted in serious degradation of the contacts.

Day 10 - Monday.

Interview with the Senior Operator.

- The Senior Operator has set up a 3 or 4 machines in the workshop to allow him to dub and perform some basic production work. This is because the mobile studio is often in use and it allows him to do basic work without tying up the mobile. He has been an operator for approximately 20 years and displays a high degree of proficiency when performing operational work such as programme production, outside broadcasts etc. He has a basic proficiency in matters relating to the internal operation of circuitry or system faults. His use of tools is limited to the repair of leads, physical alteration of equipment (e.g. making a jig for microphones or new ways of mounting aerials).

- The Senior Operator related his experience on the course he attended in Japan. The course was for 3 months and was on audio engineering. The course was conducted by NHK in Japan and was funded by Japan International Cooperation Agency (JICA). Course participants included others from the Pacific (PNG), Africa, and Asia He provided me with the course materials he had been given. In summary, the course was split between three areas of training - the first, theoretical principles of audio engineering ranging from tape recorder principle of operation, digital audio broadcasting to radio frequency principles (AM, SW, FM). The circuit operation of equipment specific to NHK (e.g. a short wave transmitter) was also provided. They also performed some practical work in the recording of a musical group and performed some field recordings using Digital Audio Tape recorders/players. Another area of the course were on-site visits to various NHK sites.

- In reviewing the course materials, I was interested in a general consensus which formed among participants in their evaluation forms of the course. This consensus concerned the need for a greater practical orientation of the course which was able to assist them more directly when they returned back to their organisations. Out of the seven participants, five identified a need for more practical training within the course.

- The senior operator had mixed feelings about his experience in Japan. He decided to return home 1 month early but did not provide specific reasons for his return except that he was "home sick". He spoke often about the food - commenting that he usually teamed up with his friend from Papua New Guinea to go looking for a Macdonald's. Another factor was language. English is a second language to him and he is, at first, difficult to understand because his English is somewhat limited - particularly when he needs to describe the behaviour of equipment. He found the English of the Japanese difficult to understand. Also, much of the course was conducted in Japanese with a translator providing a commentary of the lecture. This was also commented upon by the Senior Operator as a difficulty he had to contend with. Despite these problems the Senior Operator still considered the experience worthwhile. He discovered some new techniques for microphone placement as well as experiencing Japanese culture and hospitality.

Interview with the Technician

- I also spoke with technician about the course he attended in Malaysia. At the time of this discussion, he was repairing an aerial cable. The cable was a spare but they always tried to have a spare on hand as these cables often break during use on outside broadcasts.

- The course in Malaysia was a tape recorder maintenance course and was conducted by the Malaysia national broadcaster on behalf of the AIBD (Asian Institute for Broadcasting Development). The course duration was 4 weeks. A female announcer also went to Malaysia during this time to attend another course. Both commented to me they felt home sick. The technician was particularly concerned that should something happen to his recently-born baby while he was away he should be contacted so he could return immediately. They looked forward to their return home so much so they both had their bags packed a week before departure.

- The course materials were showed me to me by the technician. The first publication was familiar to me as a publication produced by the ABC on "Magnetic Tape Recorder Principle" the original source of which was drawn from an Ampex publication. The remaining course material were selected sections from manuals for specific brands and models of tape recorders - (e.g. Otari MX 5050, Studer A 807) The sections were maintenance instructions and specifications.

- The Technician commented about the practical sections as being directed to equipment which the radio station didn't possess. RDAT field recording is now the main method at Radio Malaysia as opposed to the radio station's use of analogue Nagra machines (a professional quality analogue tape recorder). On commenting that he would like to line up a Nagra they had to go looking for one to dust from the cupboard. The technician told of the Radio Malaysia staff's amusement that the equipment which was most relevant to the Technician's training was at the back of a cupboard and not in common use by Radio Malaysia.

  "They all laughed at me when I said I wanted to practice on a Nagra"

- The Technician also related his experiences at the recent Pacific Games held in Pago, American Samoa. As Pago is about 70 miles away they experimented a few weeks prior to the game with a direct radio link from Pago to Apia to carry the commentary of various events. The radio station has a formidable capacity for outside broadcasts which is difficult for the rivals (in Apia and in Pago) to copy. The successful

broadcast of live events from Pago was a crowning achievement for the engineers. An indication of their success was demonstrated by locals in Pago listening the radio station's commentary broadcast from Apia (the radio station can be monitored in Pago).

Interview with the Trainee

- The trainee is a recent graduate from the recently established Polytechnic in Electronic Engineering. I discovered he had a good understanding of components types. He had a keen interest to develop knowledge about the function of different circuit configurations. He would like to win a scholarship to either Australia or New Zealand to undertake a course in electronic engineering.

Interview with Cris Wheeler - First Assistant Secretary, Australian High Commission.

- AusAID has generally drawn away from the provision of equipment to areas which are in competition with the private sector. The forms of assistance available for broadcasting are human resource training (journalists, technical training etc). The Australian Staffing Assistance Scheme (ASAS) scheme was wound back because expatriates were filling in-line positions without an identified counterpart - "everything worked fine but when the counterpart left, the whole thing fell apart". (The reasons underlying this situation were not explained). Chris argues that a broader range of more targeted support can now be given.

- The Pacific Regional Media Training Project is aimed at providing a range of assistance from management to journalism to technical training.

- Two forms of assistance now advanced by AusAID.

  via regional organisations - coordination difficult, difficulties and politics of working together though they have some good linkages with the region

  private company - stand alone - easy to supervise but often don't make all the connections

- The other factor which struck me is the lack of continuity in project assistance e.g. he didn't know that the broadcasting department were in receipt of masts and transmitters from AusAID.

Day 11 - Tuesday.

Visit to National University of Samoa Media Centre.

- Eric is the manager of the media centre at NUS. Formerly an employee of both the radio station and the local television company, he also attended the University of the South Pacific in Fiji. The media centre is brand new and has been supplied under Japanese assistance who also built the university. Eric had no say in specifying the equipment for his unit. It appears that assumptions were made about the expected standard of professionalism as equipment was of a basic domestic semi-professional nature (e.g. Super VHS rather than Betacam). Further assistance from Japan is possible dependant on viewing of the work Eric produces. Eric is now producing an order to hopefully provide further equipment. The documentation consists of operational manuals (no technical manuals) and the prospect of machine failure appears slight at the present because it is all still under warranty.

- Eric attended a 6 month AusAID sponsored course in Video production in Melbourne. He found that he was way ahead in the technical aspects but found the course quite valuable in scripting and pre-prediction techniques - he was the only Pacific Islander on the course - though there were also two Australians of Pacific Island descent (Fijian and Maori). Eric was one of only 2 people who was awarded a high distinction. He maintains contact with the two course participants of Pacific Island descent.

- He sees contact and cooperation with the local radio and television station, USP and Youth Sports and Culture as being important to assist in overcoming problems. He is the only one who has explicitly identified these contacts as being a strategy to overcome problems that arise for him. Having a diary as a constant companion, Eric appears busy but well on top of his job.

Tuesday Night:

- Swapped over Optimod signal processors in order to promote quality of channel 1's sound. The basis for competition with the FM is the audio processors which use psycho-acoustic methods to enable the AM signal to "sound" as pleasing to human ear as possible. We couldn't complete transmitter equalisation as we couldn't attain a square wave on the scope - spent a long time trying different leads.

Day 12 - Wednesday.

Lunch

- In a conversation over lunch with the pastor of a church I was invited to attend, I discussed the difficulties of scholarship students, as some of the young people in the congregation had similar experiences. His attitude was in accord with the general feeling that these people had let the side down. While he acknowledged that it is tough in terms of one's loneliness and separation from family (that is a given as it effects all people) there is a feeling that those who have failed to complete their course did not do enough to overcome these problems.

  "We all know it is tough to be lonely and be away from family and friends but we all have to live with that.... There is a feeling there that they did not do enough to put those difficulties behind them and get on with the job"

- Certainly, the reverse is true - those who return with their qualifications are celebrated with their achievement seen as a source of considerable pride for the whole family. Not that this is uncommon quite generally, there is a recognition that it is tough for those studying overseas. The Chief Engineer has recounted his experience when he was in Australia. A gruelling weekend study timetable in which he would work through Friday night and Saturday morning to Saturday evening. Saturday and Sunday were for sleeping. The marks chief engineer received from his study were excellent (80% +)

Interview with the Manager.

- The manager did not realise that I was leaving on Thursday. She had been off work because she had been sick. The illness of her brother in hospital as well as the responsibilities of an elderly mother and family finally took their toll when she collapsed at the hospital and was advised by the doctor to take a rest. Her family responsibilities as well as those of manager certainly make life busy for her. My association with the manager stretches back to my first arrival at the radio station and I have watched her steady rise in position and authority from journalist, to News Director, now to manager.

- The manager displayed considerable pride over the recent outside broadcasts undertaken by the radio station. The most recent, a tourism festival was a busy time

but she had received many positive comments from senior members of government about the coverage. Back further was the Pacific Mini-games in Pago where 2 technicians and 2 announcers spent the week covering the events. Such was the popularity of the event, positive comments came from people in Pago who listened to her radio station's broadcast in preference to their local stations.

- Turning to the affairs of the radio station she spoke to me about the major issues of concern to her. She feels satisfied with her decision to establish a new studio in Savai'i which has proved to be enormously popular with the public as well with her boss, the Minister of Broadcasting. She acknowledged that this decision did upset the technical section to some extent as it meant that the limited equipment they possessed needed to be spread even more thinly resulting in reduced operations in the main studio as well as back-up capacity. She promised the Chief Engineer more equipment but this has been a drawn out and bureaucratic process. Firstly, it took 12 months before the money was allocated in the annual budget (it was missed out on the previous budget allocation). Secondly, as all purchases have to be approved by the central purchasing authority delays often occur here.

- The manager implied that relations between her and the Chief Engineer were not open to full and frank communication. She admits that she does not have a full grasp of the technical situation at the radio station. Unlike the former manager, who had previously been an engineer and took an ongoing interest in technological developments, she relies on the chief technical officer for this information.

  '... I don't understand the technical side as well as [the former director] so I rely on [the chief engineer] to tell me what's going on. I sometimes feel he is hiding things from me and I don't know why...'

- The manager related to me a particular instance in which parliament was due to begin and one transmitter (Tx 3) was out of service. It appears that this transmitter had been out of operation for at least a number of days before hand as there had been some interruption to the broadcast of school programmes. As parliament requires both transmitters to be functional to carry the bilingual proceedings (a constitutional requirement) the failure represented not only a problem as far as listeners to the 2nd channel are concerned but a politically sensitive one. The Chief Engineer assured her that all was fine and under control. Later on that night she noticed that there was some activity at the transmitter building (doors open and lights on) and the presence of personnel from the post office (who had presumably loaned equipment for the repair or was assisting in repair). She became aware that there was no particular

certainty in the repair of the transmitter and later heard that repair efforts continued throughout the night till early morning at which time the fault was solved.

- The manager sees the provision of training to various staff members and pay rises as a considerable achievement.

- The manager spoke about the difficulties of maintaining the 120 metre transmitting mast. Its close proximity to the sea means that possible structural failure due to rust is a possibility if it is not painted every 3-5 years. The manager argues that as the Australian government supplied the mast it is quite reasonable for her to ask that they also maintain it. The imposition and high cost of maintaining the mast appears as a sting in the tail of this donation and as a consequence there is some reason to suggest that liability for its upkeep should be shared with AusAID.

Comment:
The manager's views about the mast represent an interesting counterpoint to the provision of aid. While it can be argued that AusAID provided the radio station with a good technical system which meets the requirements for adequate broadcast coverage (which is directly related to the length of the mast), the other view is one where it is an imposition to have to maintain such a large structure where there is an absence of local expertise. For example, no staff member is willing or able to climb the mast to replace the light globes. This has been done by a contractor who is able to coax one of his staff to do the job. The radio station pays approximately AUD $50 to perform this task. As the globes are on for considerable periods of time and in combination with interruptions to the power supply, the globes may only last 8 weeks. Approximate cost of repainting is approximately AUD $25,000.

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